PB-217 984

NORTH PLATTE RIVER BASIN WATER POLLUTION INVESTIGATION

Public Health Service
Kansas City, Missouri

January 1951

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Federal Security Agency
Public Health Service
Division of Water Pollution Control
Missouri Drainage Basin
Kansas City, Missouri

January 1951

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Details of illustrations in
this document may be better
studied on microfiche

Prepared by the Public Health Service at the
request of and in cooperation with the
Bureau of Reclamation, Region 7, and the
Water Pollution Control Agencies of the
States of Colorado, Nebraska and Wyoming

NORTH PLATTE RIVER BASIN WATER POLLUTION INVESTIGATION

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INTRODUCTION

The development of land and water resources of the Missouri River Basin has been envisioned by the planning agencies as a program to achieve maximum beneficial use of these natural assets. Among the contemplated uses are water needs for municipal, public health, sanitation and related purposes. The determination of these needs must be based upon reliable data on water quality and on the sources and amounts of pollution contributed to streams.

The Bureau of Reclamation, the agency primarily responsible for the development of the North Platte River Basin, believed it necessary that a pollution study be conducted in that Basin to secure ~~these basic~~ data for use in planning water utilization, to document the extent and nature of existing pollution, and to record general standards of water quality. It was agreed by the representatives of the Bureau of Reclamation, Department of Interior; the Water Pollution Control Agencies of the States of Colorado, Nebraska and Wyoming; and the Public Health Service, Federal Security Agency, that the Public Health Service would assume full responsibility for the survey and the preparation of complete reports thereof in cooperation with the State Water Pollution Control Agencies. A Memorandum of Understanding between the Bureau of Reclamation and Public Health Service was prepared and became effective December 14, 1949; a complete text of the Memorandum of Understanding is presented in appendix A.

The 'Memorandum of Understanding Respecting Joint Program for Stream Pollution Investigations of the North Platte River' states that the investigation ~~will~~ include, ~~among other things~~: "(1) A determination of the extent, types and major sources of pollution (2) a review of existing laws and pending legislation regarding pollution of public waters in the States of Wyoming, Nebraska, and Colorado (3) an evaluation of the sanitary quality of irrigation water at present and proposed impoundments, diversion points, and in existing canals (4) a recommendation regarding minimum stream flows below the reservoirs for public water supplies and for sanitation purposes with present and contemplated pollution (5) an evaluation of the sanitary quality of water for municipal requirements and other public uses (6) an estimate of possible benefits to abatement of water pollution problems by reservoir releases (7) recommendations and existing plans for pollution abatement".

The Missouri Drainage Basin Office of the Public Health Service initiated the development of the water pollution investigation of the North Platte River Basin, immediately after the Memorandum of Understanding became effective. The activities were carried out with the close coordination and assistance of the cooperating agencies who furnished laboratory assistance, information on water supply use, sources of pollution, stream flows at various points, and assisted in various other phases of the work.

The report as represented by this document covers the items specified in the Memorandum of Understanding. The body of the report presents general background information, critical reviews of State water pollution control laws, laboratory results, compilation and discussion of data, and conclusions and recommendations. An appendix is included for special studies, individual laboratory and flow data, and other pertinent information.

ACKNOWLEDGMENT

This report was made possible through the excellent cooperation, assistance, and support provided by the various interested State and Federal agencies, and the communities and industry contacted during this survey. This opportunity is taken to gratefully acknowledge the help rendered by all.

The investigation was conducted pursuant to the Memorandum of Understanding entered into by Region 7, Bureau of Reclamation, represented by Regional Director Avery A. Batson, who has done much to promote these activities, and the Missouri Drainage Basin Office, Public Health Service, represented by Basin Engineer Glen J. Hopkins.

Special recognition is made of the support and cooperation of the Water Pollution Control Agency of Nebraska represented by Dr. F. D. Ryder, State Health Officer, T. A. Filipi, Director of Division of Sanitation, and L. O. Vose, Director of Laboratories; the State Water Pollution Control Agency of Wyoming represented by Dr. Franklin D. Yoder, State Health Officer, and L. O. Williams, Director, Division of Environmental Sanitation; and the State Water Pollution Control Agency of Colorado, represented by Dr. R. L. Cleere, State Health Officer, and William N. Gahr, Director of Division of Sanitation.

The North Platte District Office of the Bureau of Reclamation at Casper, Wyoming, through District Manager I. J. Matthews and Planning Engineer Edwin H. George, made available salient information and provided other valuable assistance. Drafting services were furnished by that office.

Stream flow information was made available by District Engineer Douglas D. Lewis, U. S. Geological Survey, Lincoln, Nebraska, and State Engineer Dan S. Jones, Nebraska Bureau of Irrigation, Water Power and Drainage.

Studies of the Fish and Wildlife Service of the Department of Interior were of considerable value.

Technical reviews of this report were made by the Water Pollution Control Division, Public Health Service, Washington, D. C.; the Environmental Health Center, Public Health Service, Cincinnati, Ohio; and interested Federal Agencies.

The report was prepared in close collaboration with the Water Pollution Control Agencies of Colorado, Nebraska, and Wyoming, who have reviewed the report and given their approval of the contents.

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SUMMARY

The North Platte River Basin extends from north central Colorado to southeastern Wyoming and western Nebraska. From its headwaters in north central Colorado the North Platte River flows 680 miles to its confluence with the South Platte River, about five miles east of the City of North Platte, Nebraska, to form the Platte River.

Precipitation varies from 18 inches at the eastern extremity of the Basin to 15 inches in the vicinity of the foothills area of the Rocky Mountains; 40 inches and more occur at the higher elevations. Semiarid conditions generally prevail in arable sections of the Basin. Agriculture, including livestock raising and related industries, petroleum production and refining, tourist trade, and mineral products, forms the basis of economy.

Irrigation has been synonymous with the agricultural development of the Basin since the latter half of the nineteenth century. The present program for the maximum beneficial use of water resources in the Basin, as developed by the Bureau of Reclamation, includes extension of existing irrigation systems, development of additional hydroelectric power, provisions for additional recreational facilities, fish and wildlife improvements, and public health and sanitation benefits. Nine dams and reservoirs are under consideration.

In general, adequate ground water supplies are available for municipal use in Colorado and Nebraska. In Wyoming five communities with a total population served of 2,500 use surface sources; the remainder obtain supplies from ground sources. Continued growth of the Cities of Rawlins and Casper, Wyoming, may make necessary their resort to surface sources for additional water.

Water quality is generally good although high in hardness. The difficulty of finding waters having low selenium content in the area northwest of Casper, Wyoming, may lead to the use of irrigation waters for domestic purposes. This would result in a cost benefit to the development project but would create public health problems engendered by farm animal and human wastes reaching the irrigation ditches. Per capita maintenance costs would be high because of the scattered farm services.

Industry uses a large quantity of ground and surface water for processing and cooling. Most of the water required by industry is softened prior to its usage.

Thirty communities and 12 major industrial plants discharge wastes to the North Platte River and its tributaries. A large portion

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of pollution entering the North Platte is due to a seasonal load contributed by industry. Public health hazards and nuisance conditions result from the practice of discharging untreated wastes to streams. The use of polluted waters for livestock watering, and for irrigation of low-growing crops such as celery, lettuce, cabbage, tomatoes and other truck farm products to be consumed raw, is considered to be a dangerous practice.

It is generally agreed by the State Water Pollution Control Agencies that a minimum of efficient primary treatment should be provided all wastes and a higher degree of treatment instituted where conditions warrant. Removal of toxic wastes and reduction of the industrial and municipal pollutional load contributed to the North Platte River would result in great benefits to the stream. Such treatment would aid materially in the maintenance of stream conditions necessary to support a balanced aquatic life and would prevent health hazards and nuisances.

A review of existing water pollution control laws and programs including recommendations for adequate State law and for the maintenance of sufficient personnel is presented in the report.

Reservoir routing and stream regulation as proposed by the Bureau of Reclamation will effect many changes in present stream discharges. Minimum desirable stream flows at pertinent locations are specified in tables 12 and 13. Cost benefits and damages are presented in tables 12 and 14 for those localities where proposed flows under the development program may alter the degree of waste treatment required. Benefits have also been calculated for possible flow routing in accordance with minimum desirable stream flows, stable fishery values, and improvement in water quality for domestic and industrial uses. It is possible with proper flow routing to achieve in the Casper, Wyoming area an annual benefit of over $160,000 attributable to the development program. If sufficient flow is available, an additional annual benefit of about $290,000 is conceivable in the Torrington, Wyoming-Scottsbluff, Nebraska, region.

CONCLUSIONS

1. The development program of the Bureau of Reclamation for maximum beneficial use of water resources will affect stream flow and phases of public health and sanitation dependent upon provisions of adequate stream discharge. The extent of the effect, whether beneficial or detrimental, depends upon final flow routing determinations yet to be made by the Bureau of Reclamation and water uses in the affected region.

2. Public water supplies will be affected by the development program. Potentially, benefits can accrue to many of the proposed projects. At present 5 communities obtain water from surface supplies to serve 2,500 people, and 31 communities use ground sources to serve a population of 72,560.

3. Pollution discharged to surface water resources may be responsible for public health hazards and development of nuisance conditions if flows are decreased below the minimum required as set forth in this report. Thirty communities and 13 major industrial plants produce domestic and industrial wastes totaling 2,042,000 population equivalents, of which 1,840,000 population equivalents are discharged by beet sugar factories during fall operations. Existing sewage treatment reduces organic pollution, excluding the beet sugar refinery seasonal wastes, about 7 percent.

4. The North Platte River presents a picture of cleanliness in the reaches above Casper, heavy pollution from Casper to Glenrock, and gross pollution to a minimum of moderate pollution in the reaches from Torrington, Wyoming, to Lewellen, Nebraska.

5. New municipal sewage treatment plants or improvements to existing installations are needed at 22 communities; 18 require new plants, 3 need replacements for existing plants, and 1 should have existing facilities enlarged. These needs are noted in table 11.

6. New treatment facilities or improvements in present treatment methods are needed at 12 industries. Seven should have new installations and 5 need improvement in existing methods. These needs are noted in table 11.

7. The pollution control activities of the State Health Departments have been commensurate with water use, financial support, and statutory backing. Implications of the development program indicate a need for an active basin-wide program for control and abatement of pollution with adequate funds and supporting legislation.

8. Desirable mean minimum monthly flows based on a minimum of primary treatment and satisfactory stream conditions have been presented in tables 12 and 13. Wherever possible, stream regulation should consider provisions for these minimum flows. When stream regulation provides desirable minimum flows in excess of normal minimum flows a cost benefit will accrue to the construction project. Reduction of flows below desirable minimums results in damages where normal minimums exceed the regulated flow. Additional benefits are indicated for increased flow in the Casper, Wyoming, region which will assure a stable fishery and flows which will improve water quality for domestic and industrial uses.

9. The incorporation in the development program of public health and sanitation needs for water, as exemplified by the North Platte River program of the Bureau of Reclamation, is a logical and necessary step in determining the most beneficial uses of water resources.

RECOMMENDATIONS

It is recommended that:

1. A comprehensive program of water pollution control for the North Platte River be adopted by the States of Colorado, Nebraska, and Wyoming; and that such policies as may be formulated be supported by statute.

2. The States support their water pollution control agencies with sufficient funds to permit the maintenance of an adequate staff of sanitary engineers so that the comprehensive program of pollution control and abatement, including assistance and consultation to municipalities and industry, may be executed.

3. Adequate sewage treatment as discussed in the report be provided by the following communities:

Wyoming

Rawlins
Medicine Bow
Casper
Glenrock
Douglas
Guernsey
Wheatland
Lingle
Torrington
Sinclair
Laramie

Nebraska

Lyman
Morrill
Mitchell
Scottsbluff
Gering
Minatare
Melbeta
Bayard
Bridgeport
Broadwater
Oshkosh

4. All toxic materials be kept out of streams of the Basin and that waste treatment as specified elsewhere in the report be provided by the following industries:

   a. Standard Oil Company at Casper, Wyoming
   b. Socony-Vacuum Company at Evansville, Wyoming
   c. Texas Oil Company at Evansville, Wyoming
   d. Continental Oil Company at Glenrock, Wyoming
   e. Holly Sugar Company at Torrington, Wyoming
   f. Great Western Sugar Company at Mitchell, Nebraska
   g. Great Western Sugar Company at Scottsbluff, Nebraska
   h. Great Western Sugar Company at Bayard, Nebraska
   i. Great Western Sugar Company at Gering, Nebraska
   j. Cooperative Cannery at Scottsbluff, Nebraska
   k. Cooperative Oil Refinery at Scottsbluff, Nebraska
   l. Swift Packing Company at Gering, Nebraska

5. Wherever possible, the flow regulation program developed by the Bureau of Reclamation provide at least the useful desirable minimum flows as specified in tables 12 and 13 of this report.

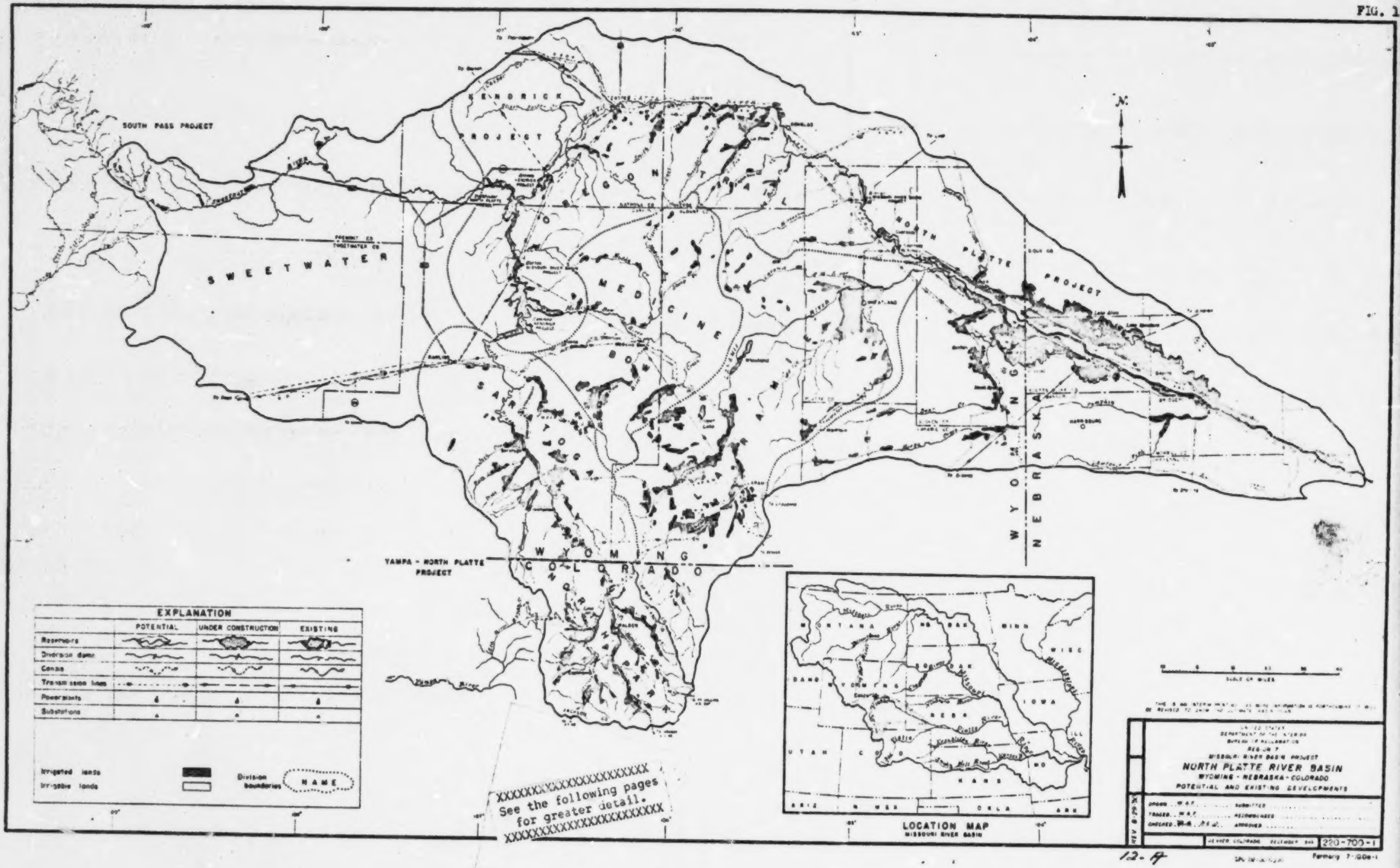
6. Consideration be given by the Bureau of Reclamation to maintaining flows at Casper, Wyoming, which will provide stable fishery values and benefits in improved water quality for domestic and industrial uses. These flows are specified in the report.

7. Caution be exercised in the use of sewage polluted irrigation waters for servicing low-growing vegetable and root crops which may be consumed raw. Chlorination of sewage treatment plant effluents to control pathogenic organisms may be a consideration.

8. Public water supplies secured from surface waters, those from shallow ground sources, and all supplies showing coliform counts in excess of acceptable drinking water standards, be chlorinated in addition to other warranted treatment.

9. Water supplies secured from sources in selenium areas be examined at least annually to assure that selenium content does not exceed the limit considered safe for human consumption.

FIG. 1


SOUTH PASS PROJECT
SWEETWATER
KENDRICK PROJECT
OREGON TRAIL
MEDICINE BOW
SARATOGA
NORTH PLATTE PROJECT
WYOMING
COLORADO
NEBRASKA
NORTH PARK
YAMPA - NORTH PLATTE PROJECT
N
SCALE OF MILES
EXPLANATION
POTENTIAL
UNDER CONSTRUCTION
EXISTING
Reservoirs
Diversion dams
Canals
Transmission lines
Powerplants
Substations
Irrigated lands
Irrigable lands
Division boundaries
NAME
LOCATION MAP
MISSOURI RIVER BASIN
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
REGION 7
MISSOURI RIVER BASIN PROJECT
NORTH PLATTE RIVER BASIN
WYOMING - NEBRASKA - COLORADO
POTENTIAL AND EXISTING DEVELOPMENTS
DRAWN W.A.F.
SUBMITTED
TRACED W.A.F.
RECOMMENDED
CHECKED
APPROVED
DENVER, COLORADO
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for greater detail.
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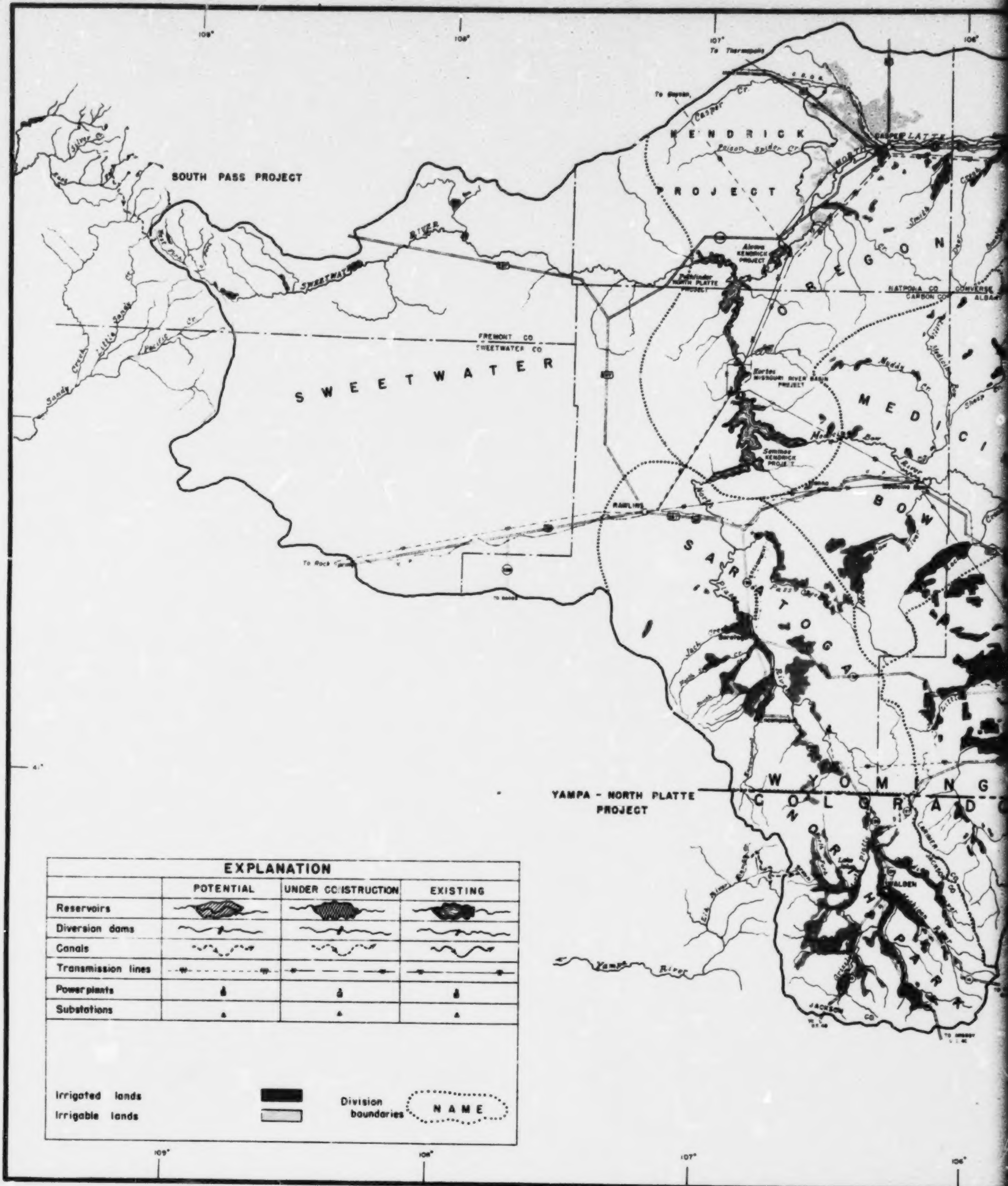
109°
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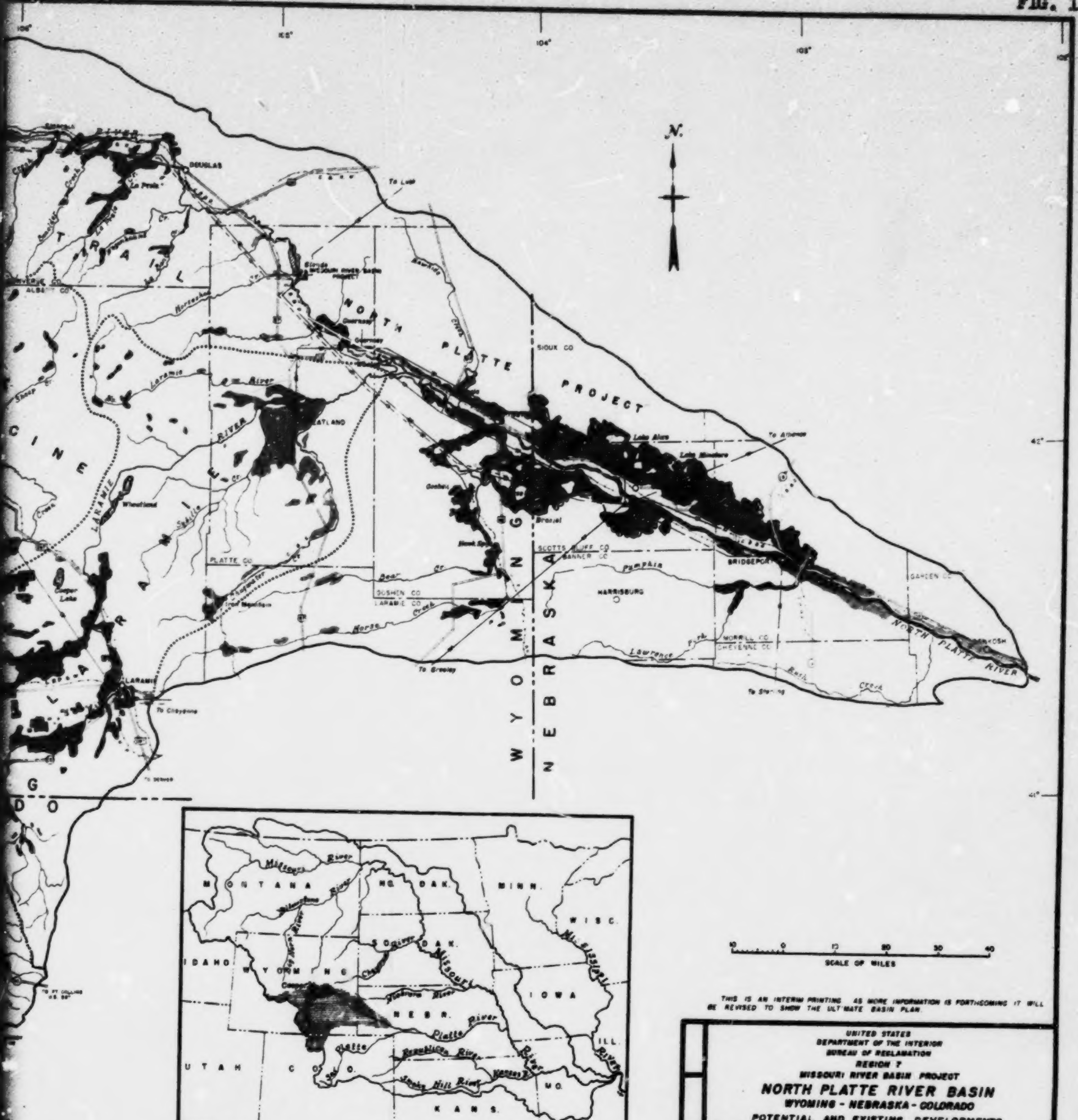
To Thermopolis
To Boysen
Casper Cr.
KENDRICK PROJECT
Poison Spider Cr.
NORTH PLATTE
CASPER
SOUTH PASS PROJECT
Sweetwater River
Alcova Kendrick Project
Pathfinder North Platte Project
NATRONA CO
CONVERSE
CARBON CO
ALBANY
OREGON
FREMONT CO
SWEETWATER CO
SWEETWATER
Sandy Creek
Little Sandy Cr.
Pacific Cr.
Kortes Missouri River Basin Project
Seminoe Kendrick Project
MEDICINE
BOW
Medicine Bow River
RAWLINS
To Rock Springs
SARATOGA
Pass Cr.
Jack Creek
Saratoga
Encampment River
41°
YAMPA - NORTH PLATTE PROJECT
WYOMING
COLORADO
NORTH PARK
WALDEN
Elk River
Yampa River
JACKSON CO
EXPLANATION
POTENTIAL
UNDER CONSTRUCTION
EXISTING
Reservoirs
Diversion dams
Canals
Transmission lines
Powerplants
Substations
Irrigated lands
Irrigable lands
Division boundaries
NAME

A

FIG. 1


106°
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DOUGLAS
To Lusk
NORTH PLATTE PROJECT
Glendo
MISSOURI RIVER BASIN PROJECT
Guernsey
SIOUX CO
To Alliance
Lake Alice
Lake Minatare
WHEATLAND
Laramie River
Horseshoe Cr.
Wheatland
Goshen
Brenel
SCOTTS BLUFF CO
BANNER CO
PLATTE CO
GOSHEN CO
LARAMIE CO
Pumpkin
HARRISBURG
BRIDGEPORT
GARDEN CO
MORRILL CO
CHEYENNE CO
Lawrence Fork
Horse Creek
Bear Cr.
NORTH PLATTE RIVER
OSHKOSH
To Greeley
To Sterling
To Cheyenne
To Denver
To Ft Collins U.S. 287
LARAMIE
MEDICINE
ALBANY CO
WYOMING
NEBRASKA
COLORADO
LOCATION MAP
MISSOURI RIVER BASIN
MONTANA
IDAHO
WYOMING
N.D. DAK.
S. DAK.
MINN.
WISC.
IOWA
NEBR.
ILL.
UTAH
CO.
KANS.
MO.
ARIZ.
N. MEX.
OKLA.
ARK.
Missouri River
Yellowstone River
Platte River
Republican River
Smoky Hill River
Niobrara River
Mississippi
SCALE OF MILES
10 0 10 20 30 40

THIS IS AN INTERIM PRINTING. AS MORE INFORMATION IS FORTHCOMING IT WILL BE REVISED TO SHOW THE ULTIMATE BASIN PLAN.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
REGION 7
MISSOURI RIVER BASIN PROJECT

NORTH PLATTE RIVER BASIN
WYOMING - NEBRASKA - COLORADO
POTENTIAL AND EXISTING DEVELOPMENTS

DRAWN W.A.F. SUBMITTED
TRACED W.A.F. RECOMMENDED
CHECKED W.A. R.C.W. APPROVED

REV. 8-29-50

DENVER, COLORADO, DECEMBER, 1949

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HISTORICAL BACKGROUND

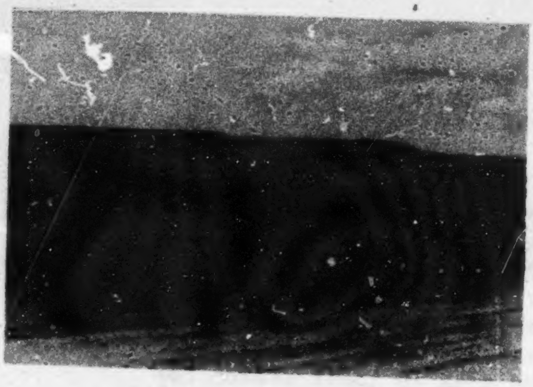
Early discoveries of the Basin may have been made by the Spanish explorers in their numerous attempts to locate riches in the wilderness. Lewis and Clark in passing through the country at the head of the Missouri River found Spanish bridles and saddles in use among the Indians; and it is known to historians who have made investigations among the Indians that the horse was acquired from the Spaniard. French trappers later entered the area in their search for fur. The main river was named "La Riviere Plate," or "Flat River," by the Mallet Brothers who translated it from the Pawnee tongue in 1739.

The Louisiana Purchase in 1803 brought most of the area into the United States. Discovery of South Pass and the Sweetwater and North Platte Rivers by Robert Stuart marked a great turning point in the history of the West. Stuart, in his journey eastward, blazed a road which corresponded to the Overland Trail, thus providing a safer and more convenient route for westward bound settlers than had hitherto been known. The first cabin in the Basin was built by Stuart at Bessemer Bend, southwest of Casper, Wyoming, in November 1812. Captain B. L. E. Bonneville and John Charles Fremont are also remembered for their explorations in the region. "Fremont Island" near Alcova was the site of one of Fremont's Camps in 1842.

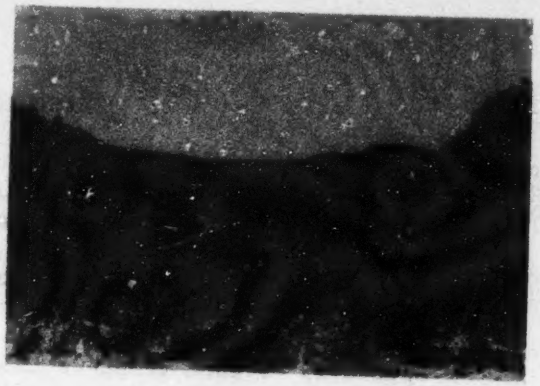
Settlers on their way to the Oregon Country named many landmarks such as the famous Independence Rock in Wyoming, known to many as the "Register of the Desert," and Scottsbluff, Jail Rocks, and Chimney Rocks in Nebraska. The Mormon and California Trails in 1847 followed the Oregon Train through the Basin and the Overland and Pony Express Routes crossed the valley. These roads were protected against the attacks of hostile Indians by a chain of forts, and one of the forts, Fort Laramie—built in 1834—became the first white settlement in the Basin.

In 1868 the Union Pacific Railroad was extended west across the Basin from Omaha and later the Chicago and Northwestern, and the Chicago, Burlington and Quincy Railroads built their lines. The improvement of transportation greatly speeded the development of the Basin, and has continued to exert a favorable influence.

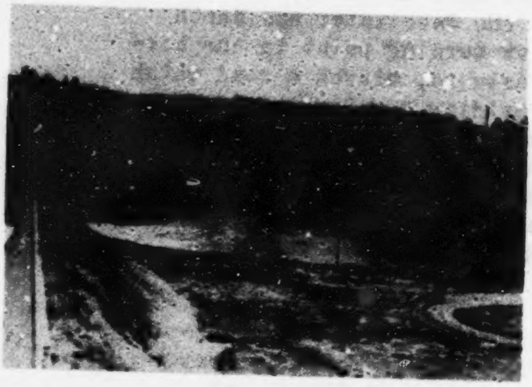
The development of irrigation in the latter half of the nineteenth century also had a marked effect upon progress in the valley and did much to disprove the nomenclature first used by Major Stephen H. Long who labeled the area on his maps as the "Great American Desert."



Alcova Reservoir from South Bank



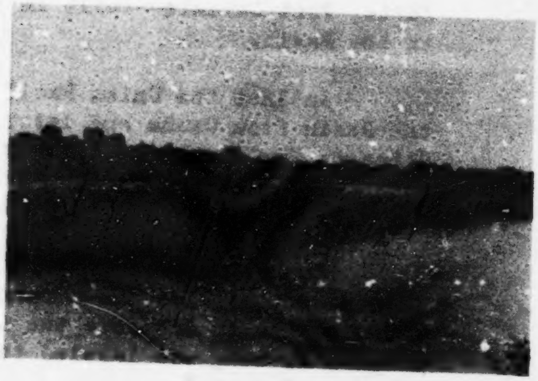
Guernsey Reservoir looking east



North Platte River below Guernsey Dam
Flow through power plant on right

Irrigation Ditch near Ft. Laramie, Wyoming

Tristate Diversion Dam near Henry, Nebraska



North Platte River near Morrill, Nebraska

PHYSICAL DESCRIPTION

Geography

The North Platte River Basin with an area of 32,360 square miles (figure 1) extends from north central Colorado to southeastern Wyoming and western Nebraska. The river rises in Colorado, flows in a northerly direction about 250 miles to the mouth of Sweetwater River where it turns northeasterly for 50 miles past Casper Mountain. Below Casper, Wyoming, it progresses eastwardly for about 50 miles and then takes a southeasterly course to its confluence with the South Platte River east of the City of North Platte, Nebraska. For the purpose of this report Lake McConaughy is taken as the eastern limit of the Basin.

Topography

The North Platte River Basin slopes eastward from the Rocky Mountains across rolling prairies into the Central Great Plains country of western Nebraska. The physiography varies from a rugged topography in the Continental Divide region in north central Colorado and western Wyoming, where snowcapped mountains and forest growth are evident, to gently sloping plains country. Swift snow-fed mountain streams have eroded the rock formations of the mountain ranges to form canyons from which the streams emerge abruptly onto gently sloping plains country. The channels are often steep but there are occasional small, narrow mountain valleys where flat side slopes and flood plains exist. Table 1 lists the tributaries of the North Platte River and their drainage areas.

Northern Colorado and southwestern Wyoming contain numerous mountain ranges including the Park Range, the Medicine Bow Range, and the Laramie Mountains. The Park Range forms part of the Continental Divide while Medicine Bow is a spur of the Front Range of the Rockies and contains the highest peaks of the southern Rocky Mountain group. The Laramie Mountains are cut by the Laramie River in the vicinity of Wheatland. South of the Laramie River the mountains are generally low rounded hills, and to the north they are higher, steeper, and angular in configuration.

Northeast of the southern Rocky Mountain Region in Wyoming, the High Plains Region predominates and extends into western Nebraska. The topography consists of broad, flat tablelands, surrounded by escarpments, isolated buttes, occasional level basins depressed below the level of the surrounding country, and ragged and eroded badland areas.

Table 1. North Platte River Basin - Principal tributaries and their drainage areas

Stream	Miles above mouth		Drainage Area* (Square miles)
	North Platte River	Tributary	
North Platte River			32,360**
Big Creek	615		201
Brush Creek	598		104
Encampment River	591		237
Spring Creek	582		160
Jack Creek	573		152
Pass Creek	545		284
Medicine Bow River	495		2,441
Little Medicine Bow River		55	1,016
Rock Creek		99	500
Sweetwater River	458		4,693
Poison Spider Creek	411		258
Casper Creek	396		634
Deer Creek	366		237
Boxelder Creek	353		196
La Prele Creek	341		211
La Bonte Creek	317		262
Horseshoe Creek	277		209
Cottonwood Creek	265		171
Laramie River	232		4,630
Chugwater Creek		24	702
North Laramie River		29	522
Sybille Creek		40	580
Little Laramie River		115	316
Sand Creek		148	187
Rawhide Creek	217		552
Horse Creek	194		1,792
Bear Creek		37	563
Pumpkin Creek	137		998
Rush Creek	106		346
Blue Creek	85		220
Birdwood Creek	23		804

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*Data from Platte River Report House Document 197, 73rd Congress, 2nd Session, Corps of Engineers.

** Area included in Basin with Lake McConaughy as eastern limit.

Climate

Precipitation varies from 18 inches in the eastern extremity of the North Platte Basin to about 15 inches in the vicinity of the foothill area adjacent to the main range of the Rocky Mountains where a gradual increase occurs until the high of 40 inches or more, containing a large percentage of snow precipitation, is reached in the higher altitudes of the range. Destructive hailstorms are not unusual.

Wide ranges in monthly and annual temperatures are characteristic of the Basin. In the Rockies, low average annual temperatures of 33° F. have been recorded, and temperatures vary from over 100° F. to -50° F. In the plains, an average of 41° F. is experienced at Laramie. Winters are usually very cold, with periods of extremely low temperatures broken by occasional warmer spells. Blizzards frequently occur in the cold weather seasons. Generally high winds blow over the Basin in early spring months, usually March and April, and low relative humidities are prevalent in the Great Plains Region. The growing season at Laramie is 113 days and at Casper about 133 days.

Hydrology

Above Seminoe Reservoir, Wyoming, the North Platte River discharges are not regulated and summer flows vary with the melting of snow precipitation. Below the reservoir the stream is regulated with variable winter and summer characteristics. Reservoirs constructed for irrigation and hydroelectric power purposes restrict flow during the winter storage period, causing greatly reduced and minimal stream discharges. During the irrigation season the stored water is discharged to meet irrigators' demands, and the North Platte flows at high stage. At Guernsey, Wyoming, the average discharge over a 44-year period of record has been 2,077 second-feet.

ECONOMIC DEVELOPMENT

Agricultural and related products, oil, minerals, and natural gas possess high dollar values in the economy of the Basin. Livestock, wheat, sugar beets, and other field crops reflect the activity of the agricultural industry in which 22 percent of the employed workers in the Wyoming section and 55 percent of the workers in the Nebraska portion of the Basin are occupied. Livestock represents the principal farm income in Wyoming (82 percent) and Nebraska (48 percent). In Nebraska, livestock is closely followed by field crops with 42 percent. The availability of an ample supply of water for irrigation, and the existence of vast grazing acreage for livestock enhance production in agriculture and related industries. Large scale irrigation projects were initiated in the North Platte River Basin in the latter half of the nineteenth century. Pathfinder Dam was completed in 1909. Irrigation development effected a stabilization of the Basin's economy. The "Rural Level of Living Index" (1940), was 120, as compared to a national level of 101.

Transportation facilities have been subjected to heavy usage since the period of early development. Several important railways and transcontinental highways, assisted by modern airway facilities conveniently situated, serve the Basin. Improved transportation has made Wyoming attractive to an increasing number of tourists who are lured by the fish and game prospects and by the scenic mountain parks and summer resorts located in the vicinity of the Continental Divide. Transportation markedly aided in making tourist trade important to the Basin.

Hydroelectric power produced at the Seminoe, Guernsey, and Lingle plants has been a great aid in the development of the Basin's resources. Through the Kendrick Project power system, an interconnection with the Riverton and Shoshone system of the Yellowstone River Basin was completed to provide standby service. An additional transmission line connects the Basin's power systems with the Colorado-Big Thompson project in the South Platte River Basin.

Population data for 33 communities are presented in table 2. The U. S. Census for 1940 reported a population of 129,469 for the area included in the Basin, and incomplete 1950 Census reports indicate an increase in this population.

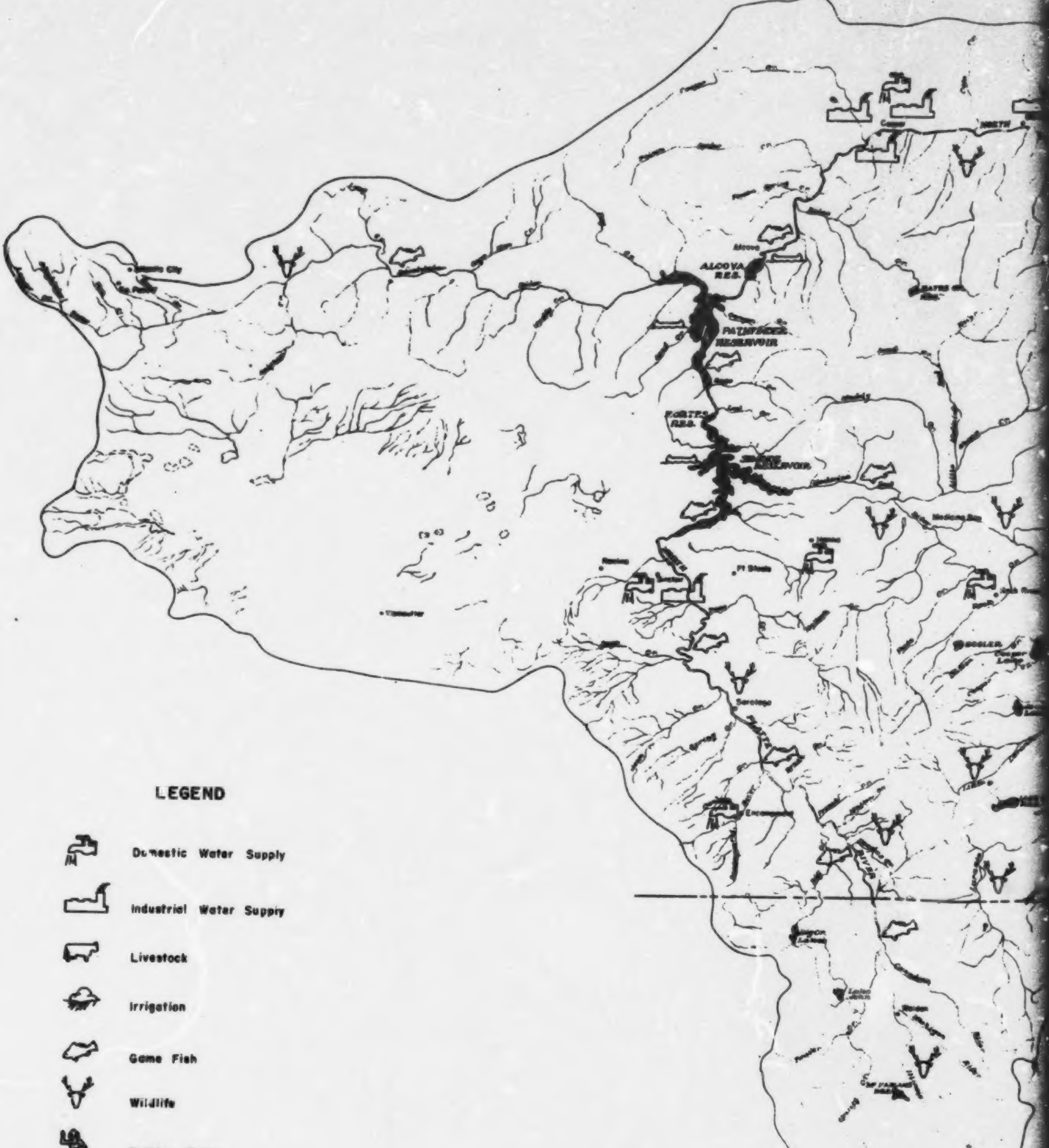
USES OF WATER RESOURCES

Water Supply

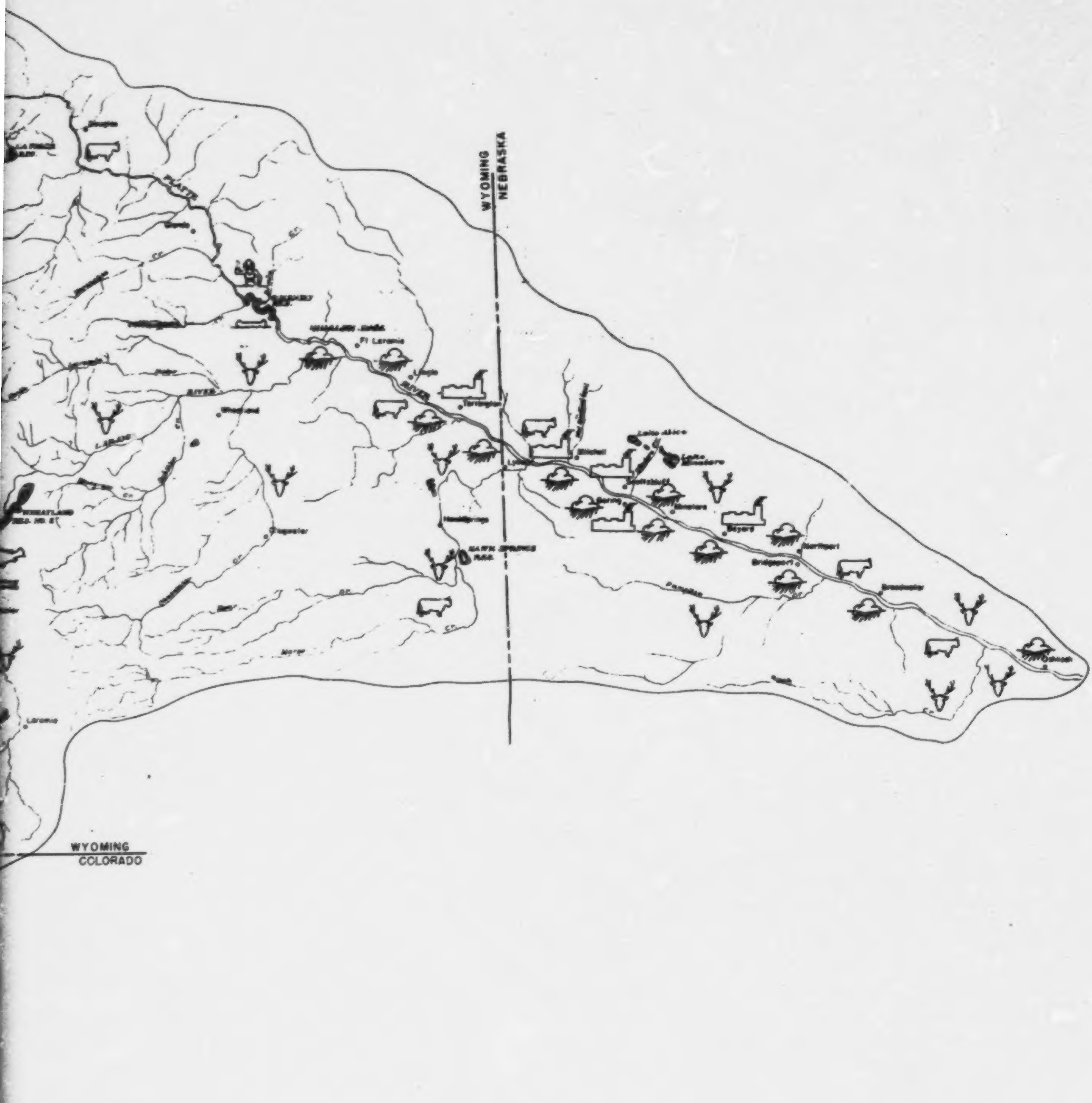
Municipal

Walden, the only Colorado community in the Basin, obtains its water from well and infiltration gallery sources. In Wyoming most Basin municipalities secure their water supplies from ground sources--wells, springs, or infiltration galleries. Surface sources are used by the Wyoming communities of Evansville, Hanna, Sinclair, Encampment, and Rock River. Basin municipalities located in Nebraska obtain their water supplies from wells varying from 20 to over 50 feet in depth. The quality of water is generally good, although somewhat hard. The water available for usage is usually adequate.

High water consumption by communities in the area is generally traced to air conditioning and garden irrigation uses. Date on municipal water supply and consumption are presented in tables 6 and 7. Average municipal consumption will exceed 13 million gallons per day.


ALCOVA RES.
PATHFINDER RESERVOIR
Alcova
Casper
Saratoga
Encampment
Medicine Bow
LEGEND
Domestic Water Supply
Industrial Water Supply
Livestock
Irrigation
Game Fish
Wildlife
Bathing Water
Other Recreation

A


PLATTE
RIVER
Ft Laramie
Lingle
Torrington
WHEATLAND RES. NO. 2
WARM SPRINGS RES.
Laramie
Lake Alice
Lake Minatare
Scottsbluff
Gering
Minatare
Bayard
Northport
Bridgeport
Broadwater
Oshkosh
WYOMING
NEBRASKA
WYOMING
COLORADO

B

NORTH PLATTE RIVER BASIN

WATER POLLUTION INVESTIGATION

WATER USE

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
DIVISION OF WATER POLLUTION CONTROL

1950

18-A

Table 2. North Platte River Basin - Population of municipalities

Municipality	Population - U. S. Census 1920	1930	1940	1950 (est.)
Nebraska				
Bayard	2,127	2,058	2,121	1,870
Bridgeport	1,235	1,421	1,520	1,620
Broadwater	364	368	344	-
Dalton	295	453	358	-
Gering	2,508	2,531	3,104	3,839
Gurley	291	232	203	-
Henry	129	167	176	-
Lewellen	-	419	532	-
Lyman	-	656	672	-
Minatare	660	1,079	1,125	-
Mitchell	1,298	2,058	2,181	2,078
Morrill	772	756	877	-
Oshkosh	707	843	910	1,111
Scottsbluff	6,912	8,465	12,057	12,833
Wyoming				
Casper	11,447	16,619	17,964	23,557
Chugwater	-	286	245	250
Douglas	2,294	1,917	2,205	2,504
Encampment	230	209	331	400
Evansville	-	174	206	300
Glendo	-	201	162	250
Glenrock	1,003	819	1,014	1,104
Guernsey	372	656	603	700
Hanna	-	1,483	1,127	1,314
Hartville	138	189	179	250
Laramie	6,301	8,609	10,627	15,497
Lingle	363	415	428	450
Medicine Bow	210	264	338	338
Mills	-	357	379	600
Rawlins	3,969	4,869	5,531	7,385
Saratoga	449	567	810	850
Sinclair	-	727	604	700
Torrington	1,301	1,811	2,344	3,207
Wheatland	1,336	1,997	2,110	2,280
Colorado				
Walden	260	284	668	683

Industrial

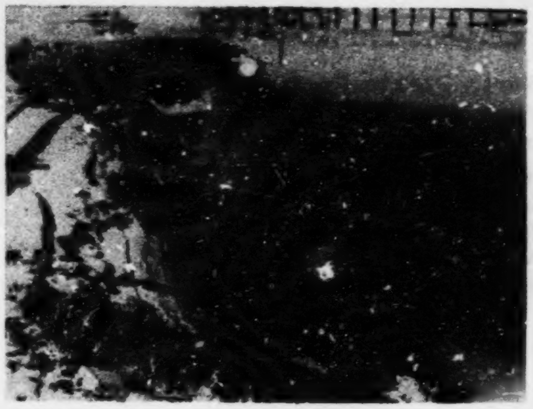
Water requirements for industrial uses in the Basin are large, depending upon the operations of the particular type of industry. Poultry dressing plants use over 500 gallons of water per 1,000 pounds live weight of birds processed. In meat packing, each ton of animals processed requires about 6,000 gallons of water. In the production of sugar 3,000 gallons of water may be used per ton of sugar beets received at the refinery. The petroleum industry uses about 770 gallons of water per 42 gallon barrel of oil. These figures are exclusive of boiler and cooling water which may greatly exceed these values. The amount of water used in air conditioning is increasing, with extended application to residences, recreational and commercial establishments, hotels, and dining halls. In this Basin, industry generally uses surface waters which may, in some instances, be supplemented by well supplies. Continued expansion of industry may be expected to accompany the development of additional irrigation and hydroelectric power projects, with a concurrent increase in the demand for industrial processing water. Industrial consumption may exceed 60 million gallons per day.

Stream Sanitation

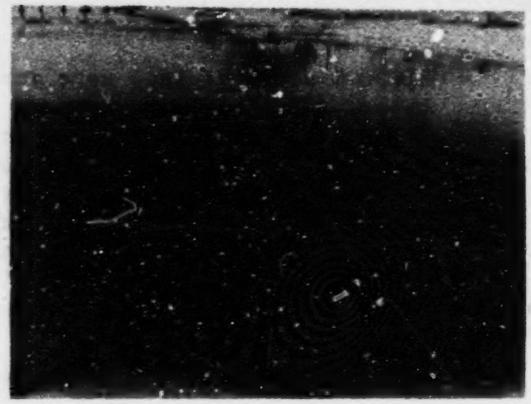
Streams in this area are used for dilution, removal, and ultimate disposal of sanitary and industrial wastes. Stream use for such purposes usually increases with the development of an area and its concurrent increase in waste products. A stream, therefore, is a factor of great financial value in the rendering of this public health service. However, over exploitation of a watercourse may result in unsatisfactory conditions when domestic and industrial wastes are discharged to a stream without adequate treatment. Waste treatment must be based upon available flow, the phenomenon of stream recovery, and downstream water uses.

Irrigation

Irrigation was introduced to the Basin in the 1850s and soon played a major role in the development of the area. At first the natural flow of the river was utilized, and early irrigation works consisted of distribution and diversion features. Primary undertakings were limited in size, and were wholly dependent upon the availability of an uncertain supply of water. In addition there were ever-present the legal matters of water use and priority rights. This was the state of affairs until 1909 when the Reclamation Service, in conformance with the early development program, put Pathfinder Dam into operation. This unit, located about 47 miles southwest of Casper, Wyoming, has a storage capacity of 1,045,000 acre-feet. Further development led to the construction in 1927 of Guernsey Reservoir near Guernsey, Wyoming, a few miles upstream from the Whalen Diversion Dam, and 50 miles west of the Nebraska-Wyoming State line. Approximately

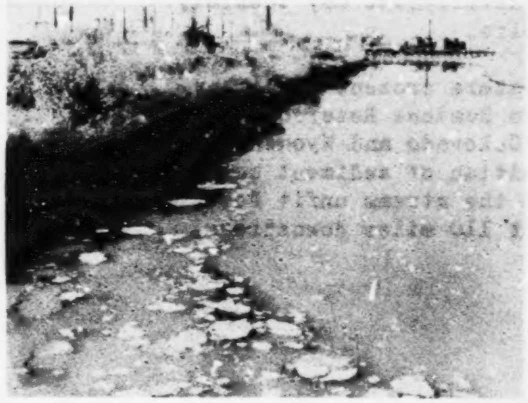


Oil (middle) and Soda Lime Sludge (foreground)
entering North Platte River
at Standard Refinery, Casper, Wyoming



Oil (middle) and Soda Lime Sludge (foreground)
spreading out into
North Platte River at Casper, Wyoming

Oil deposited along bank of
North Platte River below Casper, Wyoming



Greasy Refinery Wastes Floating on River Surface

Dried Algal Fronds on River Bed Four
Miles below Alcova Dam, October 1950

230,000 acres of land were serviced by the "North Platte Project". Later, additional storage and regulatory reservoirs, diversion structures, and distribution systems were incorporated into the project. In 1949 about 410,000 acres in Goshen County, Wyoming, and western Nebraska received irrigation waters in the Upper North Platte River Valley. Table 3 lists the number of farms and the amount of irrigated acres existing in the Basin, and figure 3 locates canals and streams on the North Platte River from Whalen, Wyoming, to Kingsley Reservoir.

Hydroelectric Power

The four existing power plants, including the Kortes unit, have a generating capacity of about 75,000 kilowatts. The North Platte River has a potential capacity of an additional 175,000 kilowatts of hydroelectric power.

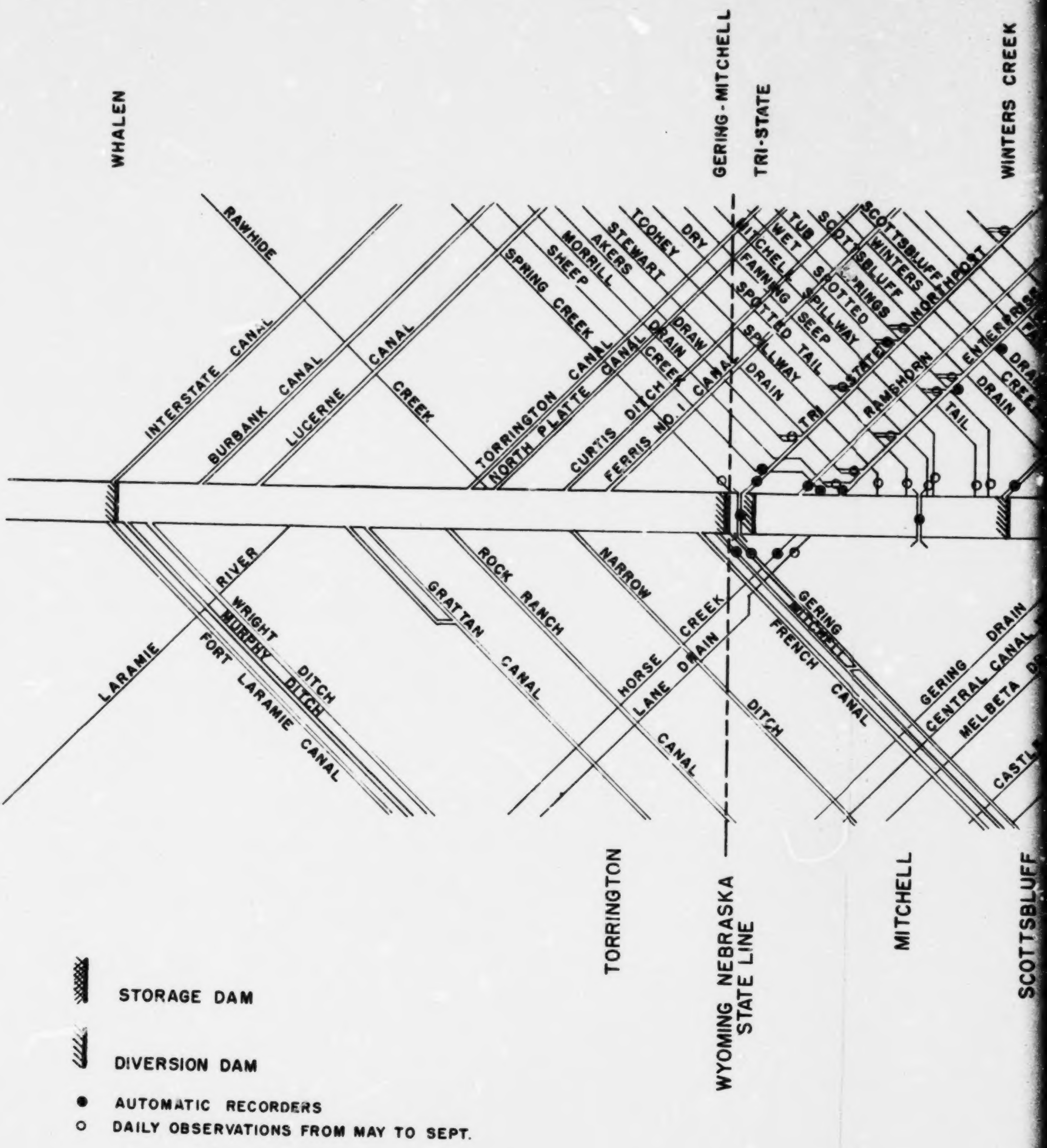
The annual average energy produced is estimated at 285,000,000 kilowatt-hours. The Seminoe Power Plant alone produces about 137,000,000 kilowatt-hours. Basin industry, private utilities, municipalities, and rural cooperatives consume the energy produced in the North Platte District. Additional power will be required for full development of the Basin's natural resources. Table 4 lists existing and potential hydroelectric power developments.

Recreation - Fish and Wildlife

Recreational facilities are numerous and readily available in the Colorado and Wyoming areas adjacent to the Rocky Mountain Region. Hunting, fishing, and dude ranching, combined with the attractions of mountain climbing and refreshing rugged topography, provide ample incentive for an expanding tourist trade.

From a basin-wide reconnaissance investigation by the National Park Service, it appears that some recreational development will be justified in connection with many Bureau of Reclamation proposals. Several potential reservoirs in the higher mountainous regions, as well as a limited number on the tributaries of the North Platte River between Casper and Glendo, Wyoming, appear to possess significant recreational values. Additional recreational development may possibly be warranted on some of the existing reservoirs.

Fish and wildlife habitat in the headwaters present ideal conditions for the sportsman and trapper. Above Seminoe Reservoir the North Platte River and tributary streams in Colorado and Wyoming are noted for trout fishing. However, the deposition of sediment coupled with the discharge of industrial wastes make the stream unfit for fishes from Casper, Wyoming, to a point about 110 miles downstream.


WHALEN
GERING - MITCHELL
TRI-STATE
WINTERS CREEK
RAWHIDE
INTERSTATE CANAL
BURBANK CANAL
LUCERNE CANAL
CREEK
TORRINGTON CANAL
NORTH PLATTE CANAL
SPRING CREEK
SHEEP
MORRILL
AKERS
STEWART
TOOHEY
DRY
DRAW
DRAIN
CREEK
CURTIS DITCH
FERRIS NO. I CANAL
MITCHELL
WET
TUB
SCOTTSBLUFF
WINTERS
SPRINGS
FANNING
SPOTTED
SEEP
SPILLWAY
TAIL
DRAIN
TRI STATE
NORTHPORT
RAMSHORN
ENTERPRISE
LARAMIE
RIVER
WRIGHT DITCH
MURPHY DITCH
FORT LARAMIE CANAL
GRATTAN CANAL
ROCK RANCH
NARROW
HORSE CREEK
LANE DRAIN
DITCH
CANAL
GERING
FRENCH CANAL
GERING DRAIN
CENTRAL CANAL
MELBETA
CASTL
TORRINGTON
WYOMING NEBRASKA STATE LINE
MITCHELL
SCOTTSBLUFF
STORAGE DAM
DIVERSION DAM
● AUTOMATIC RECORDERS
○ DAILY OBSERVATIONS FROM MAY TO SEPT.

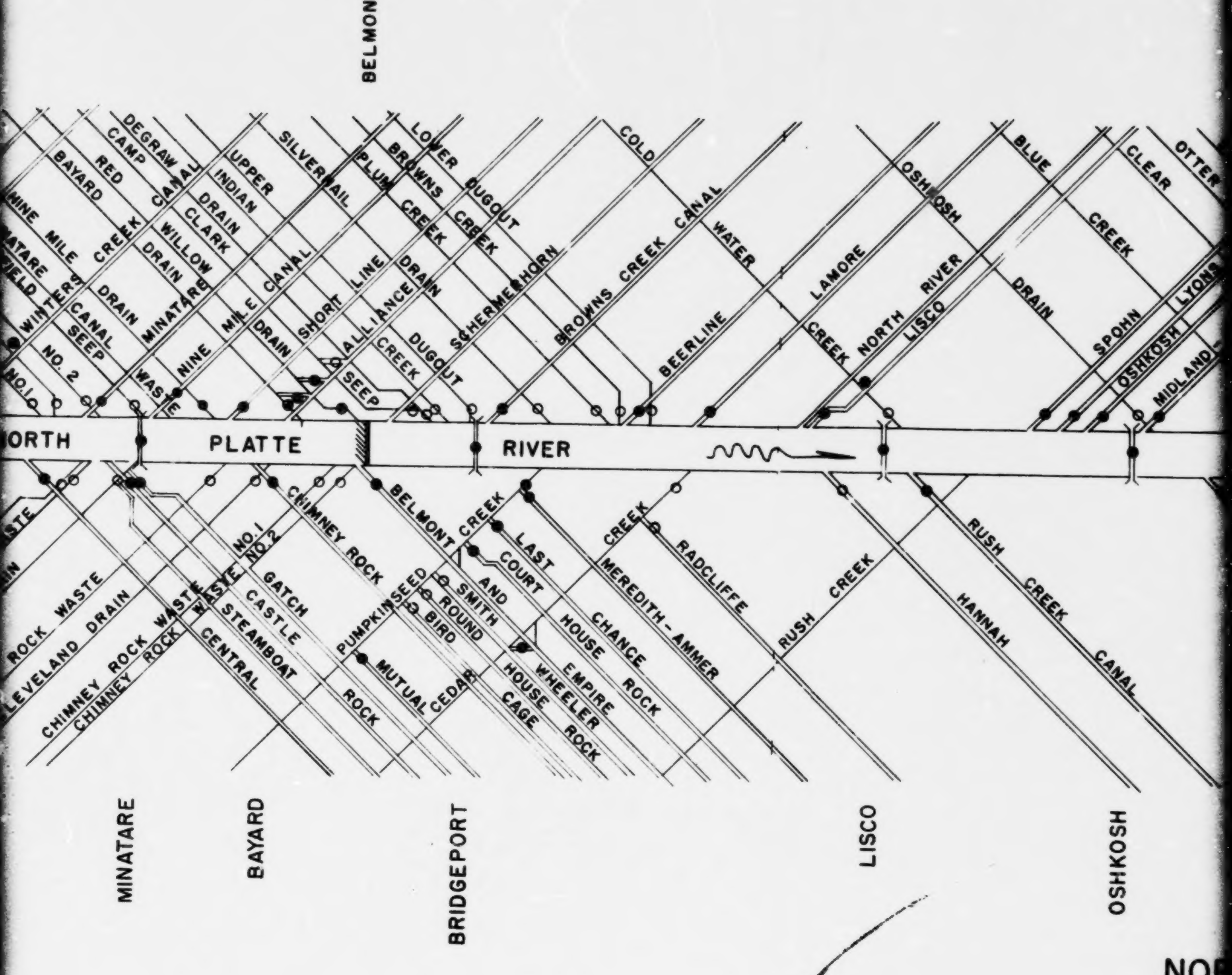

BELMONT
NORTH
PLATTE
RIVER
DEGRAW
CAMP
RED
BAYARD
NINE MILE
MINATARE
FIELD
WINTERS
NO. 1
NO. 2
CREEK CANAL
UPPER
INDIAN
DRAIN
CLARK
WILLOW
DRAIN
CANAL
SEEP
WASTE
MINATARE
NINE MILE CANAL
DRAIN
SILVERNAIL
PLUM
SHORT LINE
ALLIANCE
SEEP
LOWER
BROWNS
CREEK
DUGOUT
CREEK
DRAIN
CREEK
DUGOUT
SCHERMERHORN
BROWNS CREEK CANAL
COLD
WATER
BEERLINE
LAMORE
CREEK
NORTH RIVER
LISCO
OSHKOSH
DRAIN
BLUE
CREEK
CLEAR
OTTER
SPOHN
OSHKOSH
LYONS
MIDLAND
WASTE
DRAIN
ROCK WASTE
CLEVELAND DRAIN
CHIMNEY ROCK WASTE
CHIMNEY ROCK WASTE
NO. 1
NO. 2
CHIMNEY ROCK
GATCH
CASTLE
STEAMBOAT
CENTRAL
ROCK
BELMONT
CREEK
PUMPKINSEED
SMITH
ROUND
BIRD
MUTUAL
CEDAR
AND
LAST
COURT
HOUSE
CHANCE
ROCK
EMPIRE
WHEELER
HOUSE
CAGE
ROCK
CREEK
MEREDITH - AMMER
RADCLIFFE
RUSH CREEK
HANNAH
RUSH
CREEK
CANAL
MINATARE
BAYARD
BRIDGEPORT
LISCO
OSHKOSH

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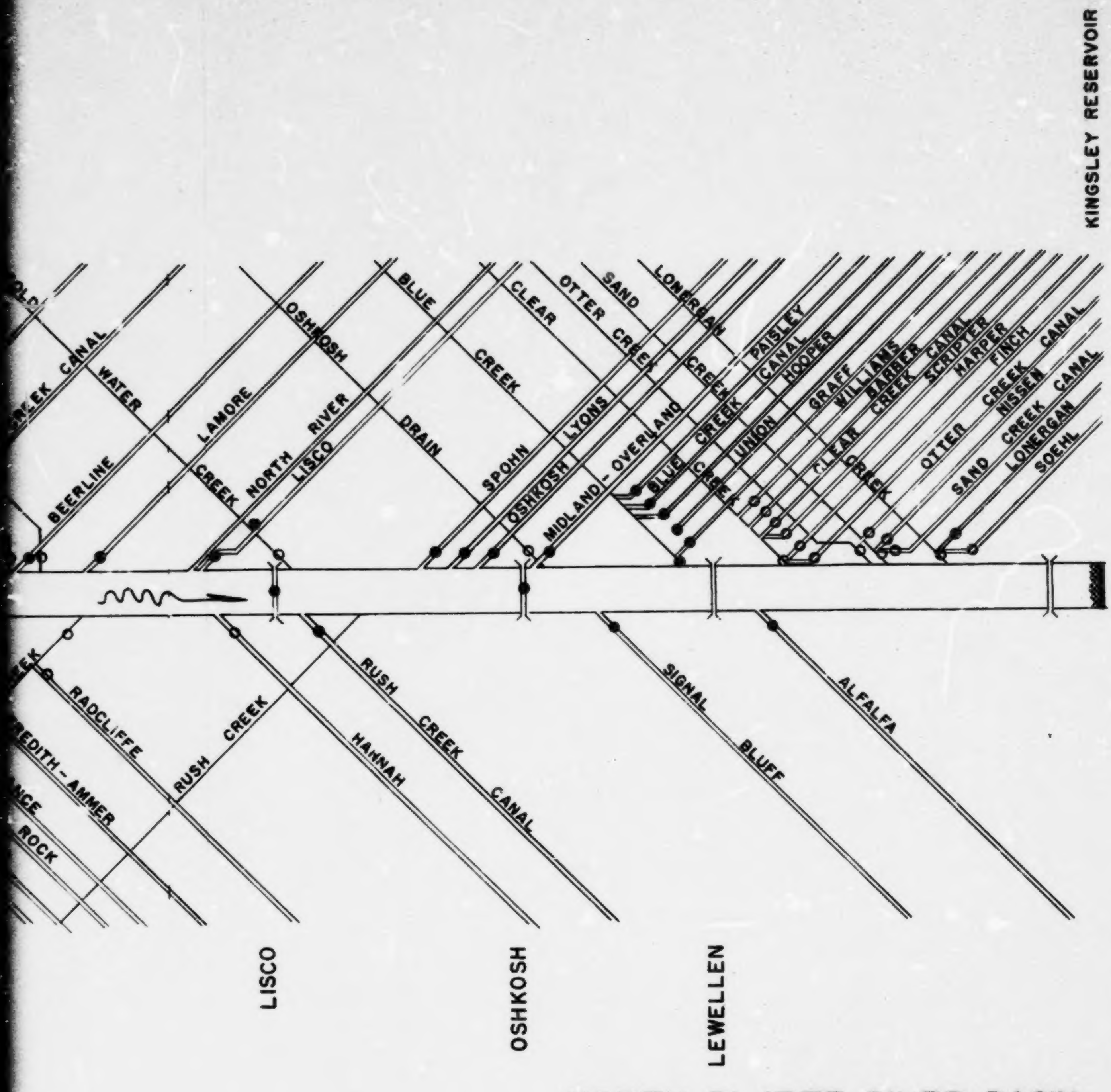
FIGURE 3


KINGSLEY RESERVOIR
OLD
CREEK CANAL
WATER
BEERLINE
LAMORE
OSHKOSH
CREEK
NORTH RIVER
NORTH
LISCO
BLUE
CREEK
DRAIN
CLEAR
SPOHN
OTTER CREEK
LYONS
OSHKOSH
SAND
CREEK
MIDLAND - OVERLAND
LONERGAN
PAISLEY
CANAL
BLUE CREEK
CREEK
UNION
HOOPER
GRAFF
WILLIAMS
BARBER
CANAL
CLEAR
CREEK
CREEK
SCRIPTER
HARPER
FINCH
OTTER CREEK
CANAL
NISSEN
SAND CREEK CANAL
LONERGAN
SOEHL
EK
RADCLIFFE
REDITH - AMMER
NCE
ROCK
RUSH CREEK
HANNAH
RUSH CREEK CANAL
SIGNAL BLUFF
ALFALFA
LISCO
OSHKOSH
LEWELLEN

NORTH PLATTE RIVER BASIN

LOCATION OF CANALS AND STREAMS

(WHALEN TO KINGSLEY RESERVOIR)

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
DIVISION OF WATER POLLUTION CONTROL
1950

C

(NEBRASKA SECTION TAKEN FROM DIAGRAM OF STATE OF NEBRASKA, DEPT. OF ROADS AND IRRIGATION.)

22-A

Table 3. North Platte River Basin - Numbers and sizes of farms in benefit counties of the North Platte River Basin[1]

County	Total land area	Total area in farms	Total number farms	Average size all farms	Total irrigated area	Number irrigated farms	Irrigated acres per farm	Average size irrigated farm	Number non-irrigated farms	Average size non-irrigated farms
Jackson	1,038,720	350,789	262	1,339	154,279	211	731	1,526	51	565
Larimer[3]	275,180	21,040	20	1,052	4,098	16	256	1,200	4	460
Albany	2,816,000	1,468,810	458	3,207	127,506	323	395	3,921	135	1,499
Carbon[3]	3,899,430	1,988,400	398	4,993	157,073	372	422	5,103	26	3,464
Converse[3]	1,381,780	1,127,600	271	4,154	22,813	148	154	3,880	123	4,500
Fremont[3]	1,159,290	129,000	30	4,300	14,790	30	493	4,300		
Goshen	1,427,200	1,097,556	1,328	826	96,018	758	127	427	570	1,358
Natrona[3]	1,902,875	1,010,550	201	5,027	20,700	90	230	6,695	111	3,675
Platte	1,352,960	1,528,491[2]	778	1,965	71,582	445	161	2,432	333	1,340
Scotts Bluff	464,640	464,640	1,900	245	200,468	1,719	117	200	181	668
Sioux[3]	327,880	285,965	354	808	31,500	250	126	304	104	2,019
Morrill	897,920	781,893	1,007	777	79,962	590	136	412	417	1,292

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[1] Data from Bureau of Reclamation - Source: 1940 Census of Irrigation.

[2] Excess of farm acreage over land area due to entire acreage of a farm being included in county in which headquarters are located even though part of farm may be situated in adjoining county.

[3] Adjusted to include only that part of county lying within Basin.

Table 4. North Platte River Basin - Hydroelectric Power Plants[1]

Plant	Number of Units	Nameplate Capacity Kilowatts
Existing		
Seminoe	3	32,400
Guernsey	2	4,800
Lingle	4	2,600
Kortes (under construction)	3	36,000
Potential		
Parkview Hill	2	20,000
Bennett Peak[2] and	1	6,300
Baggott Rocks	1	9,000
Fort Steele	-	4,300
Seminoe Additions[3]	-	10,800
Pedro	2	18,000
Fremont Canyon[4]	2	48,000
Alcova[4]	2	36,000
Bessemer Bend[5]	2	14,000
Glendo	2	24,000
Guernsey Additions	1	10,000
Lingle[6]	1	34,000
Northport	2	10,000

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[1] Data from Bureau of Reclamation.

[2] The Bennett Peak and Baggott Rock power unit is based on upstream storage in Parkview Hill Reservoir.

[3] Seminoe Additions do not include another unit, but the alteration of runners on the existing installed turbines.

[4] Fremont Canyon and Alcova Power Plants are considered as having downstream storage in the Glendo or Bessemer Bend Reservoirs.

[5] Bessemer Bend Power Plant is considered as having downstream storage in the Glendo Reservoir.

[6] The Lingle Power Plant is a new power plant with the existing power plant being dismantled.

The Fish and Wildlife Service has placed a conservatively estimated benefit of $50,000 per year to fishing if the river reach between Casper and the potential Glendo Reservoir would be improved to support game fish. According to the Fish and Wildlife Service, "The improvement of the river may be achieved only by the maintenance of substantial flows throughout the year in the 147-mile reach of river from Alcova Dam to Glendo Reservoir." Improvement of the river would require that "all practicable measures for pollution abatement be undertaken." Studies have shown the desirability of prohibiting untreated sanitary and industrial wastes and all wastes noxious to aquatic life from being discharged to the river. The report of the investigation by the biologist of the Missouri Drainage Basin Office indicates that industrial wastes have destroyed aquatic life in the North Platte River below Casper, Wyoming (appendix C).

RESERVOIR AND DIVERSION DAM PROJECTS

Major reservoirs and diversion dams are presented in table 5. Many of the structures listed as potential are in the preliminary planning stage. Those located above Seminoe Reservoir will probably have little effect upon reservoir routing schedules now planned.

Existing Projects

The "North Platte Project" included several major storage reservoirs, diversion structures, canals, and two hydroelectric power plants. Among these were Pathfinder Dam, Whalen Diversion Dam in Wyoming, and Lakes Alice, Winter Creek, and Minatare regulation reservoirs in Nebraska. Later Guernsey Reservoir was completed. Two hydroelectric plants included in the project are located at Lingle and Guernsey, Wyoming.

Development of the Kendrick Project, northwest of Casper, Wyoming, included Seminoe and Alcova storage reservoirs. Hydroelectric power units are located at Seminoe. Below Seminoe Reservoir the Kortes hydroelectric power dam is in operation, but is not yet fully completed.

Potential Projects

Multiple purpose projects for water supply, irrigation, hydroelectric power, sedimentation, recreation, fish and wildlife, public health, and sanitation are included in the development program. A review of potential[1] projects in the program of the Bureau of

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[1] The words "proposed" and "potential" are used interchangeably. In conformance with the interest of the "Comprehensive Plan of the North Platte River Basin" of the Bureau of Reclamation, both should bear the portent of the word potential.

Table 5. North Platte River Basin - Reservoirs and diversion projects[1]

Unit	Stream	Miles above mouth		Status
		Main Stem	Tributary	
Parkview Hill Dam	North Platte River	632		Potential
Bennett Peak Dam	North Platte River	600		Potential
Ft. Steele Dam	North Platte River	530		Potential
Seminoe Dam	North Platte River	482		Existing
Kortes Dam	North Platte River	480		Existing
Pedro Dam	North Platte River	466		Potential
Pathfinder Dam	North Platte River	452		Existing
Alcova Dam	North Platte River	442		Existing
Bessemer Bend Dam	North Platte River	411		Potential
Duck Creek Municipal Water Supply Dam	Deer Creek	366	20	Potential
La Prele Dam	La Prele Creek	341	15	Existing
Glendo Dam	North Platte River	280		Potential
Diversion Dam	Cottonwood Creek	265	21	
Diversion Dam	Cottonwood Creek	265	19	
Guernsey Dam	North Platte River	251		Existing
Whalen Diversion Dam	North Platte River	240		Existing
Pioneer Canal (Pioneer Canal diverts water to Lake Hattie Reservoir)	Laramie River	232	169	Existing
Lake Hattie Dam	Laramie River	232	169	Existing
Wheatland Dam #2	Laramie River	232	75	Existing
Cooney Hills Regulating Reservoir	Sybille Creek		54	Potential
Gray Rocks Dam	Laramie River	232	9	Potential
Mitchell-Gering Diversion Dam	North Platte River	201		Existing
Tri-State Diversion Dam	North Platte River	198		Existing
Winter Creek Diversion Dam	North Platte River	179		Existing
Belmont Diversion Dam	North Platte River	151		Existing

[1] Data from Bureau of Reclamation

Reclamation is presented to show the contemplated water use in the Basin. The plan is tentative and is subject to change contingent upon future developments by the Bureau of Reclamation.

Parkview Hill Dam on the North Platte River would impound water to be diverted via tunnel and canal to Parkview Hill Power Plant, which would discharge at the confluence of Big Creek and the North Platte River.

At Bennett Peak a dam and power plant on the North Platte River would discharge water at the power plant tailrace for downstream use at the Baggot Rocks power plant. Water passing through the afterbay of the latter power plant structure would be diverted into potential Pass Creek Canal or directly to the North Platte River.

Fort Steele Dam on the North Platte River near Fort Steele, Wyoming, would impound water for generating power in a hydroelectric plant. Return waters would be discharged to the stream for storage in Seminoe Reservoir.

Pedro Mountain Dam would raise the elevation of upper Pathfinder Reservoir to provide additional storage and energy capacity. Water passing through the power plant turbines would be discharged to lower Pathfinder Reservoir.

Potential Fremont Canyon Power Plant will use releases from Pathfinder Dam for the generation of hydroelectric power. Water released for power generation at Fremont Canyon Power Plant will be stored in Glendo Reservoir.

Bessemer Dam would be located in the canyon between Bessemer and Casper Mountains and would supply water for the adjacent power plant. Used waters would be returned to the North Platte.

Kendrick Unit No. 2, located near Casper, Wyoming, would be serviced by waters diverted at existing Alcova Diversion Dam and an extension of existing Casper Canal.

Duck Creek Municipal Water Supply Dam would be located on Deer Creek to store water for use in Casper, Wyoming. Intercepted water would be conveyed from the reservoir to a diversion dam where the water would be discharged into a pipe line and carried to the water distribution system of Casper.

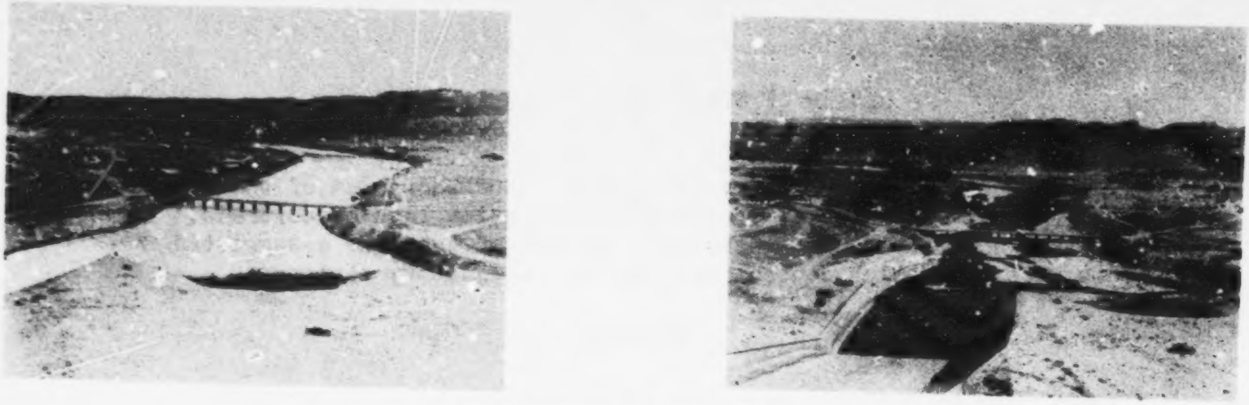
Glendo Dam and Power Plant at Glendo, Wyoming, and Alcova Power Plant as planned will use run-of-the-stream flow and will not affect stream discharge quantities. Proposed Glendo Reservoir is planned for the storage of releases from existing Alcova Reservoir, tributary runoff, and return flows from Kendrick Irrigation Project; and for production of hydroelectric power during the irrigation season, flood control and detention of silt.

Braziel Regulating Reservoir is a potential impoundment planned to alleviate operational difficulties and wastage of waters in the Fort Laramie Main Canal. The reservoir site is to be located about one mile east of the Nebraska Wyoming boundary.

Cooney Hills Regulation Reservoir would be located on Sybille Creek, a tributary of the Laramie River. Releases from Cooney Hills Reservoir would flow to the Wheatland Project or to Wheatlard Reservoir No. 1.

Grayrocks Reservoir, located on the Laramie River, would store water for use downstream.

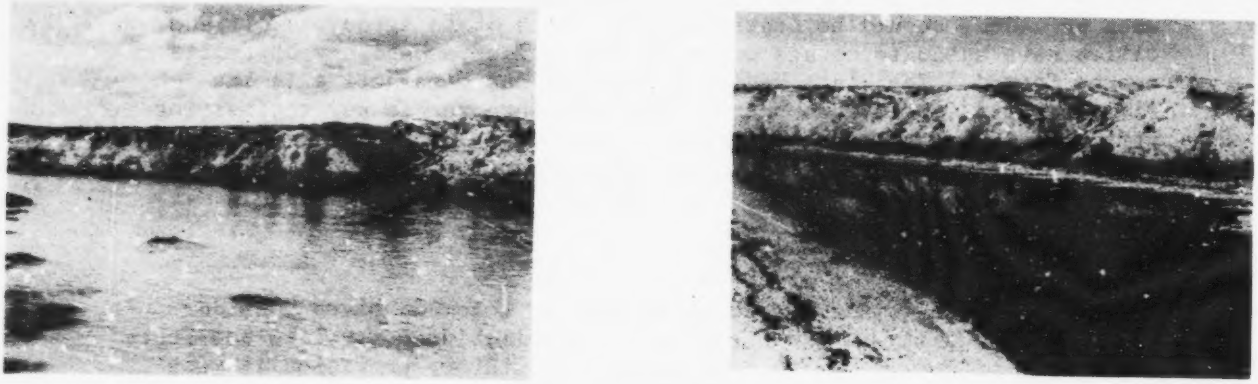
Potential Northport Power Unit is to be located in Nebraska near the towns of Northport and Bridgeport. Water would be diverted at a headgate on the Tri-State or Farmers Canal into a new supply canal and would then be directed into a penstock leading to the potential power plant. Wasted waters would pass from a tailrace canal to the North Platte River below Northport and Bridgeport.



North Platte River below Alcova Dam

High Water Stage

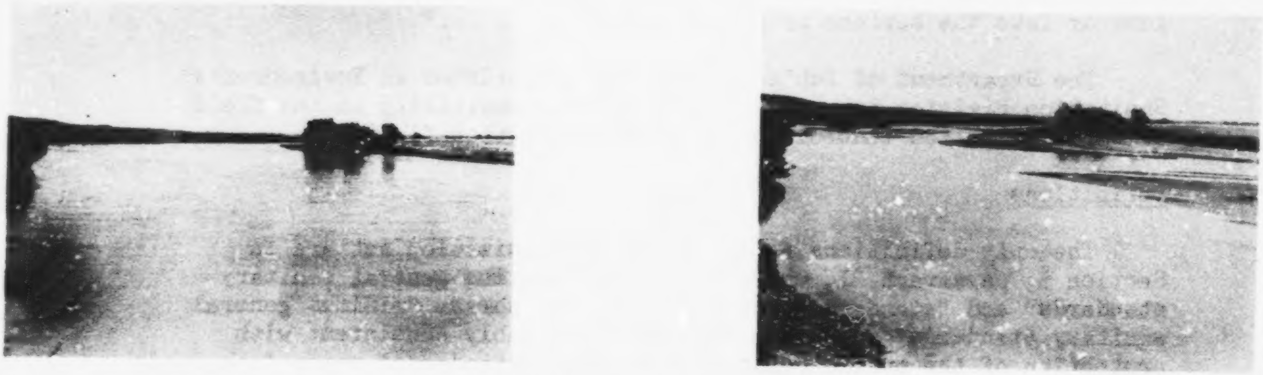
Low Water Stage



North Platte River at Mystry Bridge below Casper, Wyoming

High Water Stage

Low Water Stage



North Platte River below Douglas, Wyoming

High Water Stage

Low Water Stage

REVIEW OF STATE WATER POLLUTION LAWS

In accordance with the provisions of the "Memorandum of Understanding", appendix A, a review of the water pollution laws of Colorado, Nebraska, and Wyoming is presented. Appendix B contains a suggested State water pollution control act and the explanatory statement.

Colorado

Summary

The State Department of Public Health has been designated as the water pollution control agency for Colorado, but it shares responsibility with other public authorities. Its powers are limited to the public health aspects of water pollution control. More detailed and broader statutory authority would be desirable and this authority, when provided, should be centered in a single State agency. Colorado cities have adequate sewage works financing laws. Sanitary districts can be formed. The State Health Department has been active in the field of water pollution control but rapid turnover in key engineering personnel in recent years and lack of personnel and funds have tended to limit the intensity and scope of this program. The outlook is for increased activity in this field, however.

Administrative Authority

Chapter 208 of the 1947 Session Laws of Colorado gives considerable responsibility in the field of water pollution control to the State Department of Public Health. No specific statutory provision is made for the administrative establishment of a water pollution control authority but in one section of this act, cited as the "State Department of Public Health Reorganization Act of 1947" the Department of Public Health is given the power and duty to establish and enforce minimum general sanitary standards for, among other things, "The effluent of sewerage systems and 'trade wastes' discharged upon the land or into the surface or ground waters . . . . ."

The Department of Public Health has established an Environmental Sanitation Division in order to meet its responsibility in the field of water pollution control and in other sanitation fields.

Definitions

The only definitions found in the reorganization act are in Section 5, paragraph 21, where the terms "minimum general sanitary standards" and "standards" are defined. The phrase "minimum general sanitary standards" means the "minimum reasonably consistent with protection of the public health". The word "standards" means "standards reasonably designed to promote and protect the public health". The term "trade wastes" used in Section 5, paragraph 7, is not defined. "Wastes" should be redefined to make it inclusive of all wastes. Definitions of other terms are also needed (see appendix B).

Powers and Duties

Comprehensive Program; cooperation - There is no specific statutory authorization for a comprehensive water pollution program although such would be desirable.

Inasmuch as the Department of Public Health may wish to cooperate with other States and the Federal Government, specific authority for cooperation in matters of water pollution control should be granted. (The State health authority has general statutory authorization for cooperation with the Federal Government). The State Department of Public Health has and is now cooperating with the Public Health Service in water pollution investigations.

Investigations - The department has general authority to investigate the causes of epidemic and communicable diseases affecting the public health. There is no express grant of visitorial powers.

Stream Standards; classification - The reorganization act authorizes the Department of Public Health to establish and enforce "minimum general sanitary standards. . . as to the quality of the effluent of sewerage systems and trade wastes discharged upon the land or into ground or surface waters". The suggested State water pollution control law given in appendix B gives the State water pollution control agency the statutory power and duty to set standards of water purity and to classify waters according to their particular uses. In contrast to this the setting of a "minimum general sanitary standard" may prove exceedingly difficult and once set might prove so rigid as to be a serious detriment to adequate water pollution control. The statute should be changed to avoid this difficulty. It should also be noted that by definition these minimum standards apply only to the protection of the public health and thus limit the activities of the Health Department which has been designated the State water pollution control agency.

Rules and Regulations; hearings - The reorganization act of 1947, Section 6, paragraph 4 authorizes the Department of Public Health to adopt rules and regulations as necessary to carry out the provisions and purposes of the act. This statute also states that all rules and regulations in force at the time of passage of the act, shall remain in full effect. All rules and regulations adopted have the force of law.

The State health authority is also specifically authorized by statute to hold hearings, administer oaths, subpoena witnesses, and take testimony in all matters relating to the powers and duties vested in it.

Permits - The permit system is not required by statute but the rules of the State health department require application to and approval by the health department before new sewage works or alterations to existing works are undertaken. Inasmuch as the system of permits for the discharge of wastes into the waters of the State is desirable, this authority should be provided by statute (see appendix B).

Orders for Pollution Abatement - The State health authority is authorized by statute to issue orders as may be necessary to carry out the provisions and purposes of the previously cited reorganization act. Apparently, however, the State health authority is limited to matters relating to public health. As far as a comprehensive water pollution control program is concerned this is a serious deficiency which should be corrected.

Plans and Specifications - Submission of plans and specifications for all type of sewage works including additions or alterations is required by the State health authority's rules and regulations. These apply to municipalities, districts, corporations, companies, institutions and persons as long as a population of more than 25 is served. It is desirable that the submission of plans and specifications be required by statute and be inclusive of all situations affecting stream sanitation (see appendix B).

Federal Water Pollution Control Act - There is no specific authority for State cooperation with the Federal Government in connection with the Federal Water Pollution Control Act. However, the reorganization act does provide general authority for cooperation with the Federal Government. The State health authority may accept, use, disburse and administer all federal aid or other property, services and moneys allotted to it for State or local public works or public health functions. Agreements as may be required as a condition precedent to receiving such funds may be entered into if not inconsistent with Colorado law and after approval by the Attorney General.

Division of Authority - The State health authority, although designated the State water pollution control agency, shares responsibility for water pollution control agency, shares responsibility for water pollution investigations and control with the State Game and Fish Commission which is responsible for mine tailing pollution and the City and County of Denver. The latter is given jurisdiction over "the South Platte River, Bear Creek and any of their tributaries above the mouth of Clear Creek". (Section 257, et seq, Chap. 48 Colorado Statute annotated, 1935). This is substantially the Denver public water supply catchment area.

It is desirable to have all pollution control work centered in one State water pollution control agency (see appendix B). Inasmuch as the State health authority already has been granted considerable authority, it may be desirable that the powers of this agency should be broadened so that it exercises control over all types of water pollution problems throughout the State.

Enforcement

The State health authority's orders, rules and regulations are backed by fairly strong penalty provisions which include both fines and imprisonment plus liability for expenses incurred by the health authorities in removing "any nuisance, source of filth or cause of sickness". Provision is made in the statutes for judicial review of decisions by the State health authority in the event any person is aggrieved by such a decision.

Section 257, et seq, Chapter 48, Colorado Statutes Annotated, 1935 provides penalties for obstruction or pollution of water courses, lakes, etc.

Sanitary Districts

There is statutory authority for the formation of sanitary districts in Colorado.

Statutes Governing Financing of Pollution Abatement Works

In general, Colorado cities have adequate authority for issuance of revenue or general obligation bonds for the financing of sewage works.

Water Pollution Control Program

While the State health department has been active in this field, many cities and industries still discharge untreated or inadequately treated wastes into the waters of the State. Surface water resources are limited and a further complication results from extensive irrigation water use. A number of critical stream pollution problems exist.

In order to conserve a most valuable natural resource and to enhance benefits from nonpolluted waters, action under existing legislation is indicated. The educational activities should be increased and intensified. Recourse to the courts may be necessary with recalcitrant cases. Efforts to secure new stream pollution legislation is indicated.

There has been considerable turnover in key sanitary engineering personnel in recent years. This plus lack of sufficient personnel and funds and inadequate statutory authority have limited the extent of the program in the past. Fortunately, the situation is now improved and the outlook is for a concerted effort by the State Department of Public Health toward better stream sanitation within statutory limitations.

Of the total Colorado population served by sewer systems, about 86 percent are tributary to some type of sewage treatment plant. However, of the total number of communities having sewer systems, only about 49 percent provide treatment. The population served figure compares very favorably with a similar national figure of about 63 percent. The percent of sewered cities served by treatment plants is substantially less than the national value of about 61 percent. The significance of these figures is that much pollution abatement promotion work needs to be done in the smaller cities in Colorado.

Nebraska

Summary

Nebraska has specific need for the enactment of comprehensive water pollution control legislation based on the fundamental principles upon which the suggested State Water Pollution Control Act (appendix B) has been developed. The existing State water pollution laws are inadequate for present day needs. The powers of the State Health Department should not be limited to the public health aspects of water pollution. They should apply to all pollution detrimental to water use and there should be no division of authority. Enabling legislation for cities appears to be adequate. Sanitary districts can be formed. The State's water pollution control program has accomplished considerable improvement but much remains to be done. Serious handicaps to this program have been lack of personnel and inadequate laws. Both of these deficiencies should be corrected.

Administrative Authority

Nebraska does not have a comprehensive water pollution law and there is no statutory requirement for the development of a broad water pollution control program or the administrative enforcement thereof. Comprehensive water pollution control legislation should be enacted as soon as possible. The only statutory authority for water pollution control in Nebraska is given in Section 81-602, Revised Statutes of Nebraska which states, "The Department of Health shall have general supervision and control over matters relating to public health and sanitation . . . . ."

The State Health Department is authorized by this statute to adopt reasonable rules and regulations as will best serve to promote sanitation throughout the State.

Definitions

Definitions of the terms "pollution", "wastes", "sewerage system", "treatment works", "disposal system", etc., should be included in comprehensive water pollution legislation adopted for Nebraska. (See appendix B).

Section 37-516, Revised Statutes of 1943, defines "refuse" as all substances harmful to aquatic life and forbids its discharge into the waters of the State. However, this statute exempts corporations, villages, and cities of the second class discharging sewage or refuse prior to August 21, 1931 and is not of great value to a general pollution control program.

Powers and Duties

Comprehensive Programs: Cooperation - The powers and duties of the State Health Department, as far as water pollution is concerned. are administered through the Sanitation Division of the Health Department whose functions are principally advisory and educational. As now administered these powers and duties relating to water pollution control appear to be limited.

The Nebraska State Health Department, while not specifically authorized to do so by statute, does cooperate with various State and Federal agencies in connection with water pollution control problems. Such cooperation should be authorized by statute.

Investigations - The State Health Department conducts water pollution investigations under the very general authority granted to it by the statutes. More specific authority would be desirable (appendix B).

Stream Standards and Classification - There is no specific authority for classification of waters according to use or the adoption of stream standards. Section 81-602 might possibly be construed to grant this authority, but specific legislation is needed.

Rules and Regulations - General health department authority for the adoption of rules and regulations is contained in Section 81-602. Specific statutory authority in the field of water pollution should be given to a water pollution control authority (see appendix B).

Permits - No permit system is now in operation. Such a system is considered administratively desirable and should be included in future water pollution control legislation.

Orders for Pollution Abatement - There is no specific authority provided by statute. Presumably, however, the State Health Department could act if there was a serious public health hazard. Specific statutory authority is needed. This authority should cover all forms of water pollution and should not be limited to public health problems alone (appendix B).

Plans and Specifications - Submission is required by the State Health Department rules and regulations for systems serving more than

25 persons. No mention is made of plans for industrial waste treatment plants, however.

Federal Water Pollution Control Act - There is no specific statutory authority for cooperation with the Federal Government in connection with the Federal Water Pollution Control Act.

Division of Authority - There is some division of authority and responsibility between the State Fish and Game Agency and the State Health Department. The State Fish and Game Agency may take action through county attorneys to secure abatement of pollution harmful to aquatic life. In the enactment of comprehensive water pollution control legislation, a single State agency should be designated and its powers should be broad enough to include this and all other types of water pollution problems.

Enforcement

Penalties are provided for failure to comply with the Health Department's rules and regulations. Fines vary from $15 to $100 for each offense. As far as water pollution is concerned, enforcement provisions appear to be deficient. This phase of a comprehensive pollution law is important and should be strengthened in future legislation (see appendix B).

Sanitary Districts

Section 31-701, et seq, Revised Statutes, Supplement,1947 indicate that sanitary districts may be formed and that such districts may provide for the construction and maintenance of necessary sewage works. (Certain areas may not be included in such districts). General obligation bonds up to 10 percent of the assessed valuation of taxable property may be issued. Revenue bonds may also be used to finance such projects and in such cases the 10 percent limit does not apply.

Statutes Governing Financing of Pollution Abatement Works

All villages and cities may issue "mortgage bonds" (Section 18-502). These bonds do not impose any general liability upon the municipality and are secured by the property; e.g., the sewage works, and revenues derived therefrom. This is the equivalent of sewer service charge financing and is undoubtedly of considerable value to the municipalities in financing sewage treatment works.

All cities and villages are authorized by Section 18-501, et seq, to own, construct, equip and operate sewage works within or outside the city or village. They may condemn the lands needed, levy taxes, issue bonds, or as previously noted, mortgage bonds in accordance with statutory provisions. Cities and villages may also adopt rules and regulations governing the use of sewers and treatment plants and charges for the use of same. If the charge is not paid, the city or village may recover by action of assumpsit or the charge may be certified to the tax assessor and assessed against the property served.

Municipal finance laws do not appear to have retarded the progress of water pollution control in Nebraska.

Water Pollution Control Program

Nebraska has a fairly good record in water pollution control and the State Health Department enjoys the confidence of State and city officials, and the public at large. Undoubtedly the State's program has been seriously handicapped by inadequate statutory backing. There is a definite need for adequate legislation. The educational aspects of the program should be improved. The holding of hearings may be desirable to intimately acquaint the public with pollution control program and to gage public opinion regarding pollution abatement procedures. Legal action against extremely recalcitrant cases may be indicated.

Another serious handicap has been lack of a sufficient number of competent engineers on the State Health Department's staff. Present key personnel are experienced and competent but cannot handle the work throughout the State unaided. Funds should be provided for increasing the engineering staff assigned to pollution control work.

Of the total Nebraska population served by sewer systems, about 46 percent are tributary to sewage treatment plants. Of the cities having sewer systems, about 56 percent provide treatment. Similar national statistics indicate that about 63 percent of the sewered population are served by treatment facilities and that about 61 percent of the sewered communities provide treatment.

Wyoming

Summary

The State Board of Health, within the Department of Public Health, has been designated as the water pollution control agency for Wyoming. However, there is some division of authority and responsibility with the Game and Fish Commission in matters of water pollution control. The State Board of Health has extensive powers and there are no statutory provisions for exemption from its jurisdiction.

There is no comprehensive water pollution control law in Wyoming. Review and approval of plans and specifications by the Board of Health is provided by statute. Adequate enforcement provisions appear to be provided by statute. Lack of satisfactory water pollution control law, insufficient personnel and inadequate funds have hampered efforts on water pollution control.

Administrative Authority

Administrative authority and responsibility are vested in the State Board of Health which has extensive powers. Relevant statutes are contained in S 63-112, 201-212, Wyoming Compiled Statutes Annotated, 1945. There are no exemptions from the jurisdiction of the State Board of Health provided for by the State statutes. However, the Indian Service assumes jurisdiction on Indian reservations for sewage disposal.

Definitions

Chapter 63-204, Wyoming Compiled Statutes, 1945, defines the term "drainage" as meaning rainfall, surface and subsoil water only, and "sewage" as meaning domestic and industrial filth and waste.

Powers and Duties

Comprehensive Programs: Cooperation - There is no statutory mandate for the development of a comprehensive program, for the prevention, control, and abatement of water pollution; such provision is deemed to be most desirable, and should be considered if recommendations are to be made suggesting statutory changes.

There is no specific statutory authority to cooperate with other States and the Federal Government. However, a pattern of cooperation with Federal agencies seems to be indicated by the biennial reports of the Wyoming Board of Health. It may be deemed desirable to provide by statute for such cooperation with the Federal Government and other States in the development of a comprehensive program.

Investigations - The State Board of Health may make investigations and issue orders, rules and regulations.

Stream Standards: Classification - There is no statutory mandate for the setting of standards of water purity and the classifying of waters according to their particular uses. Presumably this may be done under the present authority to issue regulations, however, a statutory mandate to this effect may be considered.

Rules and Regulations: Hearings - There is no provision for a hearing, but in conducting investigations the Board has the power to summon witnesses, administer oaths, and hear evidence, and the investigations may be conducted in the same manner as hearings. It is to be noted that the basic Act was passed in 1923. Since that time the value of conducting hearings has become more apparent. If any change in the statute is contemplated, consideration should be given to requiring hearings by statute unless they are already afforded by administrative action under the power to conduct investigations.

Permits - Statutory requirements for a permit system is contained in Sections 63-204; 63-205; 63-206.

Orders for Pollution Abatement - Upon complaint, the Department of Public Health may issue orders prohibiting the continuance of any pollution rendering a water supply unfit for domestic use and requiring the removal of such cause of pollution (sec. 63-207). Presumably the Department may also issue orders on its own motion. Persons aggrieved may appeal to the district court (sec. 63-209).

Plans and Specifications - Review and approval of plans and specifications by the Board of Health is provided by statute. Anyone operating a railroad, logging road, logging camp, electric plant, manufacturing or industrial plant of any kind upon or over any watershed of any public supply system is subject to these provisions. Any revision should remove limitations on who requires permits. Discretionary coverage of permits should be set up by law and administered by the water pollution control agency (see appendix B).

Division of Authority - Among the general powers and duties of the Game and Fish Commission is the power to "supervise the waters of the State pertaining to the protection, management, and propagation of fish." (sec. 47-110).

Criminal statutes make it unlawful to discharge any deleterious substance that might tend to destroy the fish or pollute or render the waters unfit for domestic, irrigation, stock, or any other purpose (sec. 47-507). Sec. 9-220 makes it unlawful to poison any spring, well or reservoir with intent to kill or injure a human being.

The powers of the State should be extended by statute to cover all types of pollution and thus center all pollution control work in a single agency.

Enforcement

Adequate investigatory powers, sanctions, and judicial review, appear to be provided for by statute.

Sanitary Districts

Specific statutory authorization for the formation of sanitation districts outside of incorporated areas was provided by the legislature in January 1950. Apparently there are adequate provisions for the formation of districts within corporate limits.

Statutes Governing Financing of Pollution Abatement Works

Wyoming has a comprehensive revenue bond law applicable to sewerage works. General obligation bonds may also be used for financing sewerage works but the total outstanding indebtedness which can be incurred by this method is limited to four percent of the assessed valuation of taxable property by constitutional limitation. This limitation does not apply to revenue bonds. Sanitation districts are authorized to issue general obligation bonds limited to 10 percent of the assessed valuation, but this provision in the act is questioned on constitutional grounds. Revenue bond issues authorized for sanitation districts are not limited. It appears that Wyoming has adequate financing for construction of public pollution abatement works.

Complaints

The Board of Health is required to investigate complaints of the mayor or health officer of any city or town or the managing board or officer of any public institution or the president of an ice company relating to pollution of water used as a source of water supply used by them. It is suggested that these restrictions be removed and that the water pollution control agency be permitted to administratively determine when investigations are necessary.

Water Pollution Control Program

The State is showing increased activity in the matter of water pollution control. A major investigation has recently been completed and others are contemplated within the limitations of available funds and personnel.

The educational activities of the water pollution control agency should be increased and intensified. Wyoming, being a tourist State offering a wide variety of recreational pursuits, must protect its vital natural resources. Accordingly, the State has considerable need for adequate treatment of sewage and industrial wastes. The State water pollution control agency should hold hearings to publicize these needs and provide for pollution abatement to the extent permitted under existing law. Efforts to secure new stream pollution legislation is indicated.

Only about 37 percent of the sewered population in the State (1940) are served by sewage treatment of some sort. The national average is about 63 percent. Less than half (43 percent) of those communities with sewer systems provide some type of sewage treatment as compared with the national average of about 60 percent.. There would appear, from these figures, to be quite a fertile field among the cities and towns of Wyoming for promotion of water pollution abatement activities.

SURVEY METHODS

In planning the stream pollution investigation of the North Platte River, it was recognized that the stream could be readily separated into three distinct reaches. The upper reach from the headwaters to Casper, Wyoming, being almost entirely free of the effects of pollution, would need less investigational effort than the reach from Casper to Guernsey or the reach from Torrington, Wyoming, to Lewellen, Nebraska. Pollution from the Casper area was known to be quite intense and that specific problems involving both domestic organic waste and industrial organic and toxic wastes would be encountered. The pollution problems in the third reach of the stream - from below Guernsey Reservoir to Lewellen, Nebraska - were known to be intense and highly seasonal due to the industry located along the stream in this vicinity.

In order to secure data needed to properly evaluate the pollution and its effect on the stream, the investigation was divided into five phases. The first phase involved a study of the river from below Torrington, Wyoming, to Lewellen, Nebraska, during the month of June 1949. This study was undertaken to learn the effects of pollution from domestic sources only, in contrast to the effects of the intense pollution to be incurred during the season when the beet sugar refineries were operating.

The second phase of the investigation was the intensive sanitary study of the River from Casper to Guernsey during December 1949 and January and February of 1950. The purpose was to determine the conditions in the river under ice cover and during low flow when toxic industrial wastes were likely to exert their greatest effect.

The third phase included a comprehensive biological study of river conditions from Alcova Reservoir to Lewellen. This was a continuing operation lasting from July 1950 until November 1950 and was made to determine biological conditions during both high and low flows in the river, and during intensive pollution from the sugar refineries.

The fourth phase was inaugurated in October 1950 in order to study the effects of the discharge of large quantities of sugar beet wastes into the reach of the river from Torrington, Wyoming to Lewellen, Nebraska.

The fifth phase of the field investigations included an engineering evaluation of all sources of industrial and municipal pollution on the entire river and its tributaries. This phase of the work was carried on during the greater part of 1950.

This investigation of water pollution and water utilization in the North Platte River Basin included:

(a) Assembling and reviewing existing information.

(b) Securing of most recent and accurate information regarding (1) water supplies and water utilization, (2) sources of pollution including sewage treatment, sewage discharge and industrial wastes.

(c) Sampling program and laboratory determinations to secure various physical, chemical and bacteriological information on stream conditions as a means of correlating actual stream characteristics with sources of pollution.

(d) Securing stream discharge data at time of sampling so that laboratory results could be evaluated quantitatively with sources of pollution.

(e) Assembling and evaluating data.

Field Investigations

Field surveys of water supplies and sources of pollution were conducted by sanitary engineers from the Colorado, Nebraska, and Wyoming State Water Pollution Control Agencies, and the Public Health Service[1].

Laboratory studies supplemented engineering evaluations of major sources of pollution in many instances. Industry responded admirably to the solicitation of their cooperation and assistance, and in the Casper-Glenrock region established routine sampling and waste gaging programs, including the analyses of various chemical and physical properties of the wastes. This program is being maintained by the industries for an extended period.

Water Supply

The water supply data collected for each municipality included the source of supply, treatment if any, population served, and average consumption. Latest population estimates were employed in most cases to arrive at the population served by water systems. Industrial and agricultural use of water was also investigated.

Sources of Pollution

Domestic Sewage - For each municipality the data gathered included the sewered population, type and degree of treatment if any, and receiving body of water. The percentage B.O.D. removal by treatment plants was taken as 35 percent for primary treatment and 75 percent for secondary treatment where records or supplemental information were not available. The judgment and experience of the investigating engineer was depended upon to evaluate treatment processes where inspection indicated exceptionally good results, an overloaded plant, or inefficient or faulty operation.

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[1] The assistance of Senior Sanitary Engineer Hayse H. Black, Environmental Health Center, Public Health Service, in industrial investigations is gratefully acknowledged.

Industrial Wastes - All industrial establishments discharging a significant pollutional waste were investigated to secure information in sufficient detail to permit a quantitative evaluation of the pollutional load in terms of population equivalents. Survey data obtained from industries included the following information: type of industry, location, operation (with seasonal variation), water supply, quantity of raw materials, quantity of finished products, treatment of wastes if any, and receiving body of water. The larger industrial plants received evaluation reports for review and comment prior to these reports becoming record. In all instances completed reports were reviewed and approved by the State water pollution control agency.

The principal industries encountered in this area are meat packing, dairy, poultry dressing, beet sugar refining, and oil refining.

Sewered Population Equivalent - The industrial waste was expressed as population equivalents based upon 0.167 pounds per day of 5-day 20° C., Biochemical Oxygen Demand (B.O.D.) per person. The sewered population equivalent of the industrial wastes was added to that of the sewered population and shown as the total sewered population equivalent. The waste discharged was the sewered population equivalent minus that portion removed by treatment either by the municipality, industries, or combination thereof.

Stream Evaluation

Sampling Procedure - Stream sampling stations were established at water supply intakes, above and below sources of known or suspected pollution, in the vicinity of locations of dams and diversions, at points where other water uses might develop, and at appropriate points at the mouths of tributaries. In areas where significant pollution was expected intermediate points were added. Conveniently located bridges were utilized wherever possible for sampling locations. In the absence of bridges, suitable walk-in points were selected.

Sampling was conducted to secure a representative portion of the stream in question. The sample was drawn from the main channel or channels, and if at all possible, from mid-depth. Generally, a copper depth sampler was employed, however a special pole-type sampler was used when sampling with the copper depth sampler was not possible.

Industrial waste samples were obtained by frequent, periodic collections during an operating cycle, usually 24 hours, which were composited according to the waste flow. In this fashion a representative sample of the waste characteristics was assured.

The sample collector recorded the time of day to the nearest minute when a sample was collected and determined the temperature of the water to the nearest degree centigrade. The sample collector also recorded as "remarks" any unusual stream conditions, noted the presence of possible sources of pollution, and other pertinent information.

Samples were transported in special carrying cases in the truck or car. The containers, which were regular cold drink insulated coolers, were iced when necessary. In one end of the box a metal frame was installed that could hold a 25-pound cake of ice in place while the balance of the box held a frame having thin slatted partitions for dissolved oxygen, bacteriological and biochemical oxygen demand sample bottles. Samples were placed in the insulated box as soon as collected and remained there until ready for analysis. It was the practice to collect samples in the morning and have them at the laboratory by 2:00 p.m. at the latest so that analyses could be initiated with a minimum of elapsed time.

Number of Sampling Stations - A total of 62 sampling points for chemical and bacteriological samples were established. Two hundred sixty-five samples were collected and 2,230 analyses were completed. Industrial samples were secured from oil refineries and 60 chemical tests were made.

Stream Discharge Data

In order to correlate laboratory results with the pollution reaching the rivers it is necessary to secure actual stream discharges at the time of sampling. Arrangements were made with the North Platte District Office, Bureau of Reclamation at Casper, Wyoming, and the District Office, Geological Survey at Denver, Colorado, and Lincoln, Nebraska, to develop cooperative action to secure this information. Lists of sampling stations and itineraries of sample collectors were forwarded to the Geological Survey, who then correlated their activities with the sampling routes. Sample collectors were also instructed on methods of reading gages and staging streams and these records which included the gage reading or stage height, time and date of sampling, sampling point, location, and river mile index, were submitted to the U. S. Geological Survey for flow determination. At the request of the U. S. Geological Survey temperature readings were also transmitted for their information and use. Stream discharges are included with the laboratory data in appendix F.

Special Investigations

Industry - The major sources of industrial pollution were carefully investigated to determine the amounts and characteristics of the wastes discharged. Usually a conference was arranged with plant management to permit a discussion of the over-all problem and to secure the cooperation of the industry in the evaluation of the wastes. These meetings required advance planning to permit adequate and proper representation by industry and the State water pollution control agency. Excellent cooperation was received from industry in all cases. Details of processes, production units, chemicals employed, and wastes produced, permitted reasonable estimates of pollution equivalents which were generally substantiated by waste and stream analyses. A report of these investigations is present in appendix D.

Biological Study - A biological investigation of the North Platte River was undertaken to establish the biological picture of the river and to ascertain the effects of industrial wastes upon aquatic life. This study included chemical, physical and biological analyses of stream samples. The report is presented as appendix C.

Laboratory Operations

Four laboratory units at various times conducted analyses during the summer and fall seasons of 1949, and the winter and fall seasons of 1950. One mobile trailer laboratory was made available by the Environmental Sanitation Division of the Public Health Department of the State of Wyoming; fixed laboratories were: (1) established by the Public Health Service at Kearney Army Air Base, (2) the Laramie County Health Unit Laboratory at Cheyenne, Wyoming, and (3) the Western Branch of the Nebraska State Health Department at Scottsbluff, Nebraska.

Laboratory Resources

Mobile Laboratory - This mobile laboratory arrived at Casper, Wyoming, to initiate a sampling and testing program for the 1949 fall period in the river reach Casper to Torrington. Actual work began in October and was completed in December.

Kearney Laboratory - The equipping of a fixed laboratory at the Kearney Air Base was started on April 28, 1949, during the investigation of the Lower Platte River Basin. In anticipation of the need for an investigation of the North Platte River Basin, sampling along this river from the Nebraska-Wyoming State line to Lake McConaughy was begun June 5 and was carried on through June 27, 1949.

Cheyenne Laboratory - Samples collected during February 1950 from Casper to Guernsey Reservoir were analyzed at the laboratory of the County Health Unit at Cheyenne, Wyoming. The objective of this investigation was to ascertain stream conditions during the low flow winter period.

Scottsbluff Laboratory - This laboratory is the fixed laboratory of the Western Branch of the Nebraska State Department of Health. Samples were collected for the investigation of river conditions from Torrington, Wyoming, to Lewellen, Nebraska, during the fall 1950 sugar beet season. The initial sample was collected October 23, 1950; final analyses were completed November 3, 1950.

Miscellaneous - Samples to be analysed for phenol were sent to the Environmental Health Center in Cincinnati, Ohio; one sample was shipped to Professor O. A. Beath, Professor of Research Chemistry, University of Wyoming, to be analysed for selenium.

Total Number of Determinations

Two hundred sixty-five stream samples were collected and 2,230 determinations made. In addition, samples and analyses were made of numerous industrial wastes.

Laboratory Tests and Their Significance

Routine laboratory tests included temperature, turbidity, dissolved oxygen, biochemical oxygen demand, pH, alkalinity, chloride, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, and coliform group organisms. Other tests were phosphate, hardness, phenols, copper, selenium, and settleable and suspended solids.

Temperature - The temperature of a water is one of the factors which controls the oxygen solubility and thus the saturation level of dissolved oxygen in the stream. The rate of natural purification and bacterial growth is affected by changes in temperatures.

Turbidity - Turbidity of water is due to suspended matter. Suspended material may be particles that will settle out on standing or may be colloidal in nature. Turbidity measurement gives an approximation of the amount of silt or suspended material carried by the stream. To a limited extent a correlation exists between turbidity, suspended matter, and high and low stream stages.

pH - pH is defined as the negative logarithm of the hydrogen ion concentration. The pH value indicates the relative acidity or alkalinity of a water, with the neutral point at pH 7.0. Values lower than 7.0 indicate the presence of acids, above pH 7.0 to 14.0 the presence of alkalies.

Alkalinity - The alkalinity of a water usually indicates the presence of carbonates, bicarbonates, hydroxides, and occasionally borates, silicates and phosphates. In comparison with pH, alkalinity may be considered as a quantity factor while pH would be an intensity factor.

Chloride - The chloride content of a stream in many cases can be used as an indication of the entrance of domestic sewage or trade wastes.

Dissolved Oxygen - Normally the amount of oxygen dissolved in stream water is limited by the saturation value (9.17 p.p.m. at 20° C. and 760 mm barometric pressure) which is a function of water temperature, but in some cases as a result of the photosynthetic action of some water plants, including algae, this value may be exceeded, causing supersaturation. To support fish and aquatic life, and for the natural aerobic purification of stream waters, dissolved oxygen must be present, the minimum quantity permissible being dependent on the quality of water desired and stream flows. Satisfactory methods of waste disposal to the streams depend on the relationship between character, quantity and strength of the wastes, and the character and discharge volume of the receiving stream. Varying dissolved oxygen values below the saturation level are an indication of the presence of organic pollution which utilizes oxygen from the stream water. A measure of the degree of pollution of a particular area is given by the deficiency in the dissolved oxygen content below saturation.

Biochemical Oxygen Demand - The standard test for biochemical oxygen demand (B.O.D.) requires five-day incubation at 20° C. of sealed samples of the water under examination and determination of the loss of dissolved oxygen during that time. Where the loss may be greater than the initial dissolved oxygen present, the sample is diluted with standare B.O.D. free dilution water and the measured loss multiplied by the appropriate dilution factor.

The B.O.D. thus determined becomes a measure of the amount of oxygen necessary to satisfy the biochemical oxidation requirements of the pollution present at the time the sample was collected. Since the amount of dissolved oxygen present decreases with rising temperatures and at the same time the rate of biochemical oxidation increases as the temperature rises, critical stream conditions result during the warm months, particularly since these high temperatures are often combined with low stream flows.

Ammonia, Nitrite, and Nitrate Nitrogen - Determination of these constituents is useful in the evaluation of the degree and probable time of pollution. They give definite evidence of stream conditions and extent of recovery or natural purification under normal stream flow. These tests may also reflect the use of fertilizers when return irrigation waters are present in the stream.

Phenol - The river and industrial samples to be tested for phenols were collected in one gallon bottles and preserved with copper sulfate. These samples were shipped from Cheyenne, Wyoming via air express to Cincinnati, Ohio, and arrived less than 24 hours after time of collection. The Environmental Health Center, Cincinnati, Ohio, made the analyses for phenol by "Gibb's" method. Phenol analyses of trade wastes were made also by the petroleum refineries. Phenol is toxic to fish and other aquatic life when present in sufficient quantity.

Phosphate - The stannous chloride method was used to determine the amount of phosphate present in the stream. The test was performed to see if return water from irrigation ditches contained significant amounts of phosphates and to provide base data for future comparisons.

Hardness - Water is rendered hard principally by the presence of calcium and magnesium, chiefly in the form of bicarbonates and sulphates, but occasionally as chlorides and nitrates and is expressed as "carbonate" and "noncarbonate hardness". The sum of these two is known as the total hardness. Hardness in waters has little to do with health, but becomes of major economic importance from an industrial and household standpoint.

Selenium - Selenium is significant because of its toxic effect. Accepted drinking water standards set the limit of selenium at 0.05 p.p.m.

Coliform Group Organisms - This determination gives the most accurate estimation of the degree of pollution by sewage, since it shows the approximate density of sewage type organisms that are normally found only in very small numbers in natural unpolluted streams. Coliform bacteria are normally present in the intestines of warm-blooded animals and are discharged in vast numbers in human feces, which constitute the main source of these bacteria in sewage.

Laboratory Procedures

Chemical and bacteriological examinations and analyses were made in accordance with "Standard Methods for the Examination of Water and Sewage" Ninth Edition, 1946, of the American Public Health Association.

During part of the survey 4 to 8 inches of ice covered the stream at some of the sampling points. It was necessary to use special precautions in collecting the samples. The water collected in dissolved oxygen and chemical sampling bottles would have frozen if left exposed to the outside air temperature. Therefore it was necessary to rush the bottles to the sample car. The problem was to keep the water sample above freezing instead of keeping the temperature of the water sample down as in warmer weather.

PRESENTATION OF DATA

Public Water Supplies

Five Wyoming communities utilize surface water supplies (table 6); the population totaling 2,500 has an average consumption of 0.76 million gallons daily. These supplies, with the exception of Sinclair, are provided by impoundments on tributary streams above major sources of pollution. Sinclair obtains water from the North Platte River. The Basin above Sinclair is not subject to major pollution. Sinclair provides sedimentation, filtration, and chlorination; Evansville, chlorination; the three remaining communities do not treat their water supplies. Figure 4 offers a graphical representation of municipal water supply data.

Table 6. North Platte River Basin - Municipal surface water supplies

Stream and Municipality	State	Miles above mouth		Treatment[1]	Population served	Average consumption M.G.D.
		North Platte River	Tributary			
North Platte River						
Encampment River		590				
Encampment	Wyo.		10	N	250	0.015
Sugar Creek		530				
Sinclair	Wyo.		8	FD	800	0.300
Tributary		502				
Hanna	Wyo.		16	N	1,100	0.165
Medicine Bow River		494				
Phieland Creek			99			
Rock River	Wyo.		77	N	200	0.030
Evansville	Wyo.	390		D	150	0.250
					2,500	0.760

[1] Treatment - F - Coagulation, sedimentation, filtration
D - Chlorination
N - None

Thirty-one municipalities obtain public water supplies from ground sources to serve 72,560 people more than 12 million gallons daily. In Nebraska, 23,360 people use 2,680,000 gallons daily; in Wyoming, a population of 48,300 uses 9,482,000 gallons daily. Walden, the only Colorado community in the Basin, supplies 10,000 gallons daily to 900 persons. Public ground water supplies are obtained from

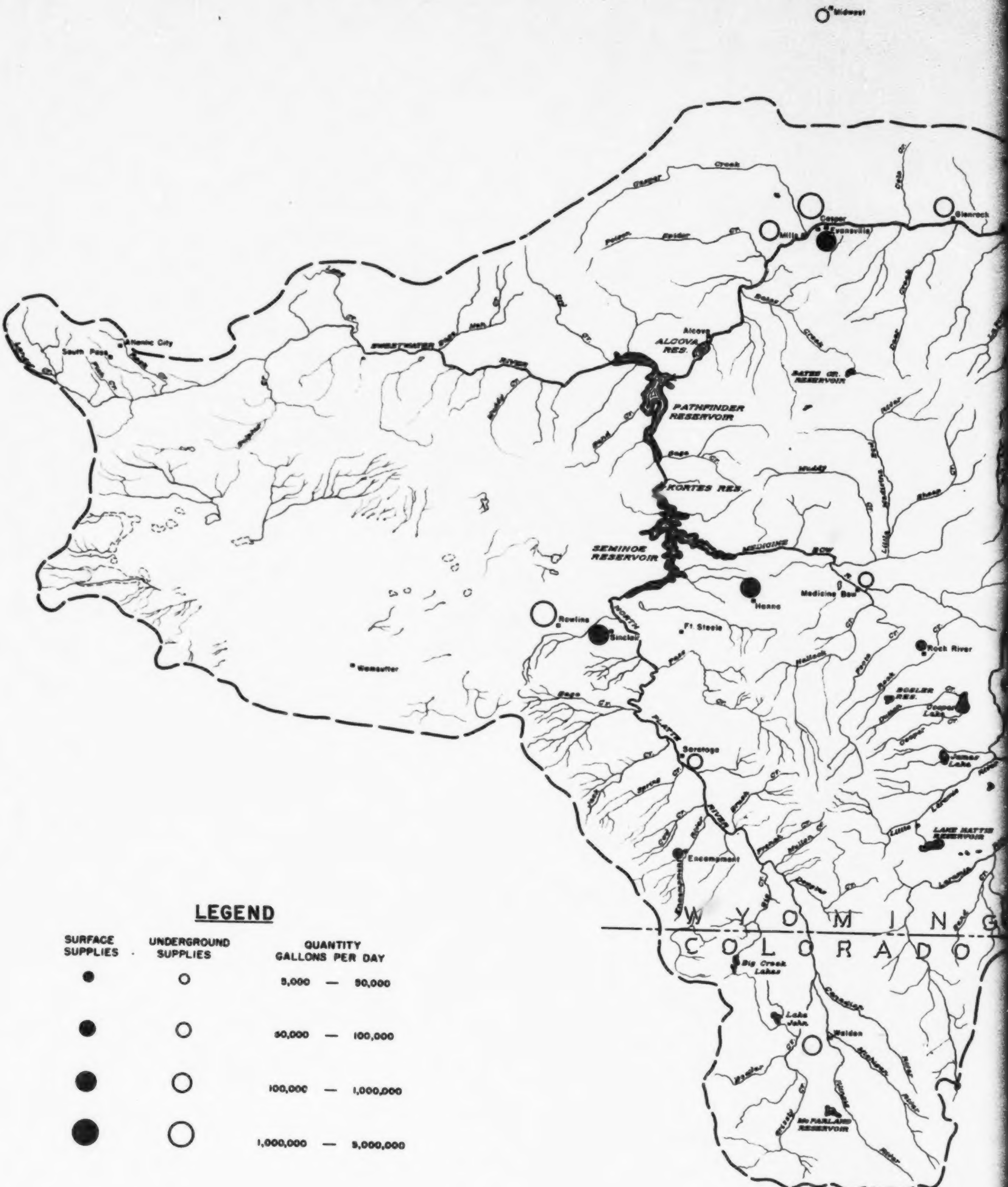
Table 7. North Platte River Basin - Municipal water supplies from ground sources

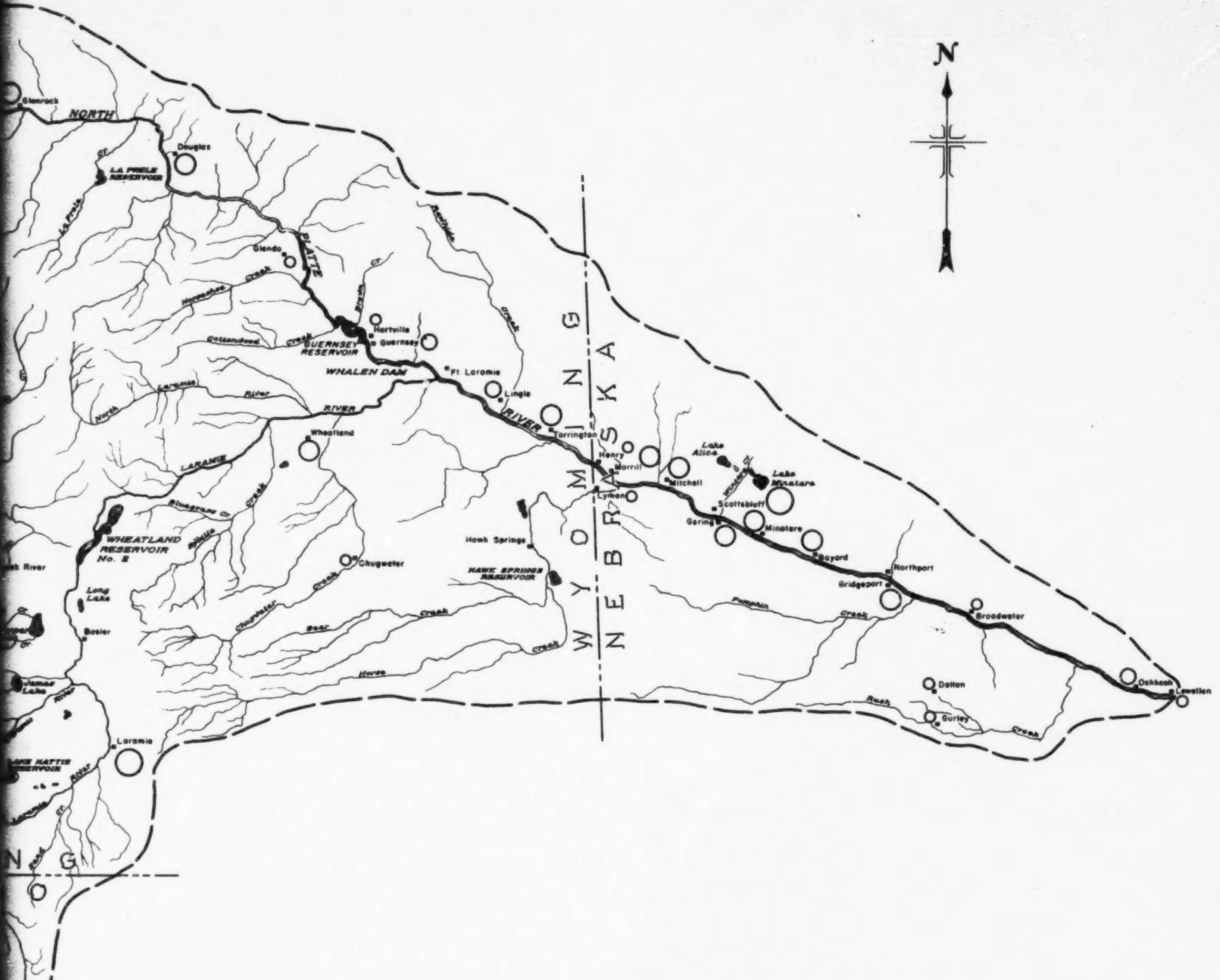
Municipality	State	Source[1]	Treatment[2]	Population served	Average consumption M. G. D.
Walden	Colo.	Inf.Gal.-W	D	900	0.10
		Subtotal		900	0.10
Casper	Wyo.	Inf.Gal.-W	D-N	18,000	1.80
Chugwater	Wyo.	W	N	230	0.022
Douglas	Wyo.	S	N	2,400	0.148
Glendo	Wyo.	W	N	180	0.016
Glenrock	Wyo.	Inf.Gal.-W	N	1,000	0.10
Guernsey	Wyo.	W	N	600	0.090
Hartville	Wyo.	S	N	180	0.017
Laramie	Wyo.	S&W	D	11,000	3.50
Lingle	Wyo.	W	N	450	0.081
Medicine Bow	Wyo.	W	N	360	0.063
Midwest[3]	Wyo.	Inf.Gal.	D-H	1,500	0.15
Mills	Wyo.	W	D	400	0.10
Rawlins	Wyo.	S	N	7,300	2.34
Saratoga	Wyo.	Inf.Gal.-W	D	700	0.055
Torrington	Wyo.	W	N	2,000	0.50
Wheatland	Wyo.	W	D	2,000	0.50
		Subtotal		48,300	9.482
Bayard	Nebr.	W	N	2,000	0.20
Bridgeport	Nebr.	W	N	1,400	0.165
Broadwater	Nebr.	W	N	310	0.025
Dalton	Nebr.	W	N	290	0.04
Gering	Nebr.	W	N	2,950	0.25
Gurley	Nebr.	W	N	180	0.045
Henry	Nebr.	W	N	130	0.02
Lewellen	Nebr.	W	N	500	0.05
Lyman	Nebr.	W	N	500	0.03
Minatare	Nebr.	W	N	1,100	0.10
Mitchell	Nebr.	W	N	2,100	0.15
Morrill	Nebr.	W	N	800	0.055
Oshkosh	Nebr.	W	N	800	0.05
Scottsbluff	Nebr.	W	N	10,300	1.50
		Subtotal		23,360	2.680
		Total		72,560	12.262

[1] Source - S - Springs
Inf.Gal. - Infiltration Gallery
W - Wells

[2] Treatment - F - Coagulation, Sedimentation, Filtration
H - Softening
D - Chlorination
N - None

[3] Midwest located out of Basin obtains water from dug wells near North Platte River.


Midwest
Casper
Glenrock
Mills
Evansville
Casper Creek
Poison Spider Cr.
Alcova
ALCOVA RES.
SWEETWATER RIVER
South Pass
Atlantic City
PATHFINDER RESERVOIR
BATES CR. RESERVOIR
KORTES RES.
SEMINOE RESERVOIR
MEDICINE BOW
Medicine Bow
Hanna
Rawlins
Sinclair
Ft. Steele
Rock River
Wamsutter
NORTH PLATTE RIVER
Sage Cr.
Saratoga
Encampment
BOSLER RES.
Cooper Lake
James Lake
LAKE HATTIE RESERVOIR
Little Laramie
W Y O M I N G
C O L O R A D O
Big Creek Lakes
Lake John
Walden
Canadian
Michigan River
McFARLAND RESERVOIR
LEGEND
SURFACE SUPPLIES
UNDERGROUND SUPPLIES
QUANTITY GALLONS PER DAY
● ○ 5,000 — 50,000
● ○ 50,000 — 100,000
● ○ 100,000 — 1,000,000
● ○ 1,000,000 — 5,000,000


N
Glenrock
NORTH
Douglas
LA PRELE RESERVOIR
La Prele
Cr.
Glendo
PLATTE
Horseshoe
Creek
Hartville
Guernsey
Cottonwood
Creek
GUERNSEY RESERVOIR
WHALEN DAM
Ft. Laramie
Lingle
RIVER
Torrington
North
Laramie
River
RIVER
Wheatland
LARAMIE
Bluegrass Cr.
Creek
WHEATLAND RESERVOIR No. 2
Sybille
Chugwater
Chugwater
Creek
Bear
Creek
Horse
Creek
Long Lake
Bosler
James Lake
River
Laramie
LAKE HATTIE RESERVOIR
Laramie
River
Cr.
N G
Hawk Springs
HAWK SPRINGS RESERVOIR
Creek
W Y O M I N G
N E B R A S K A
Henry
Morrill
Lyman
Mitchell
Lake Alice
Winters Cr.
Lake Minatare
Scottsbluff
Gering
Minatare
Bayard
Northport
Bridgeport
Pumpkin
Creek
Broadwater
Dalton
Gurley
Rush
Creek
Oshkosh
Lewellen

NORTH PLATTE RIVER BASIN

WATER POLLUTION INVESTIGATION

1950

MUNICIPAL WATER SUPPLIES

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
DIVISION OF WATER POLLUTION CONTROL

10 0 10 20 30
SCALE OF MILES

wells, springs and infiltration galleries and combinations of the same. Well water in western Nebraska is distributed without treatment. Casper, Laramie, Mills, Saratoga and Wheatland, all in Wyoming, chlorinate spring and well supplies. Midwest, Wyoming, chlorinates and softens its supply. Walden, Colorado, provides chlorination for its well supply. Data are presented in table 7 showing the population served, average consumption, and treatment, if any.

Pollution Contributed to Water Resources

The magnitude and extent of sources of pollution, described as domestic and industrial wastes and expressed as population equivalents, are presented in table 8. Nine municipalities in Wyoming discharge raw wastes to streams, 4 communities provide primary treatment, including one with practically no effective treatment, and three have secondary treatment facilities. In Nebraska, 10 municipalities discharge untreated wastes to the North Platte River and tributary streams, 1 community has a secondary treatment plant, and 2 communities utilize ineffective septic tanks. The only municipality in the Colorado section provides primary sewage treatment.

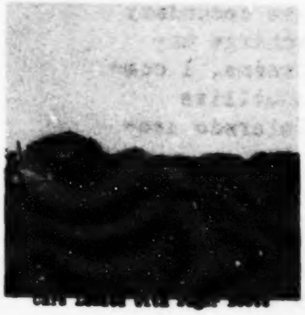
A total of 201,600 sewered population equivalents, not including seasonal industrial wastes, are reduced by existing treatment works to 187,215 population equivalents or only about 7 percent before being discharged to streams. Thirty-seven percent or 11 of the communities listed provide sewage treatment as compared to the national average of about 63 percent. Among the industries considered in the above figures are those normally discharging wastes the year around, which include oil refineries, dairies, meat packing plants, a cannery, and other miscellaneous plants. These data are depicted in figure 5.

In addition to the before-mentioned sources of pollution, seasonal operation of beet sugar refineries adds enormously to pollution problems in the North Platte Basin. Five sugar refineries produce a pollution load in excess of 1,840,000 population equivalents. There are a total of 12 major industries which contribute wastes to the North Platte River. The waste from one plant not included in the 12 is withheld completely from the stream. The population equivalents of both the major and lesser industries are depicted in table 8. It will be noted that two figures are presented in the column entitled "Industrial Waste Population Equivalents". The first figure denotes the population equivalent of the industrial waste discharged continuously throughout the year, and the second figure indicates the strength of the additional wastes of the seasonal beet sugar industry.

Six of the major industries are located in Wyoming and seven in Nebraska. The Sinclair Oil Refinery at Sinclair, Wyoming, discharges all wastes to a lagoon where evaporation equals the inflow, thus no pollution is contributed directly to the stream. Discharges from the remaining industries are not treated, although wastes from oil

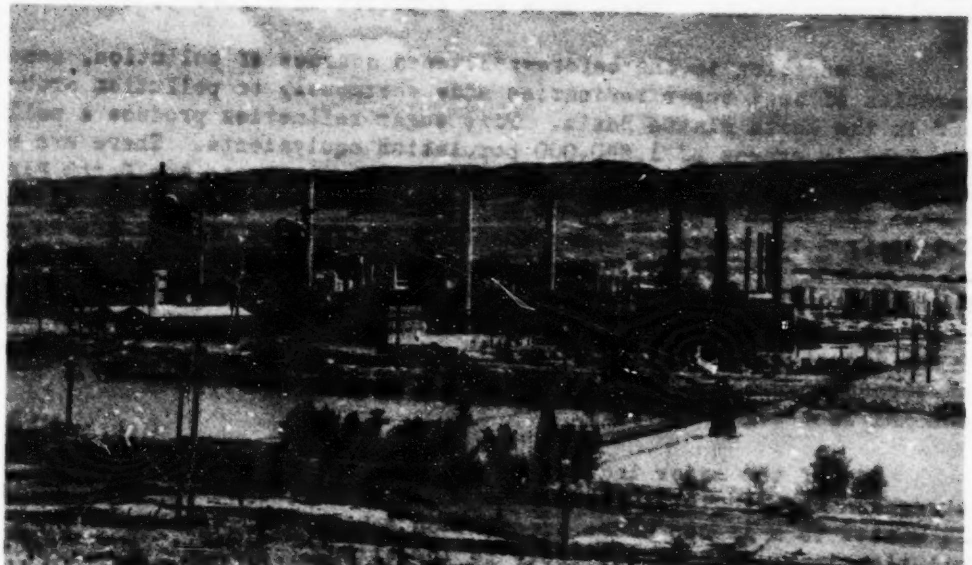
Sugar Beets on Loading Conveyor

Sugar Beet Refinery Wastes Discharging into
Drainage Ditch and North Platte River,
Scottsbluff, Nebraska

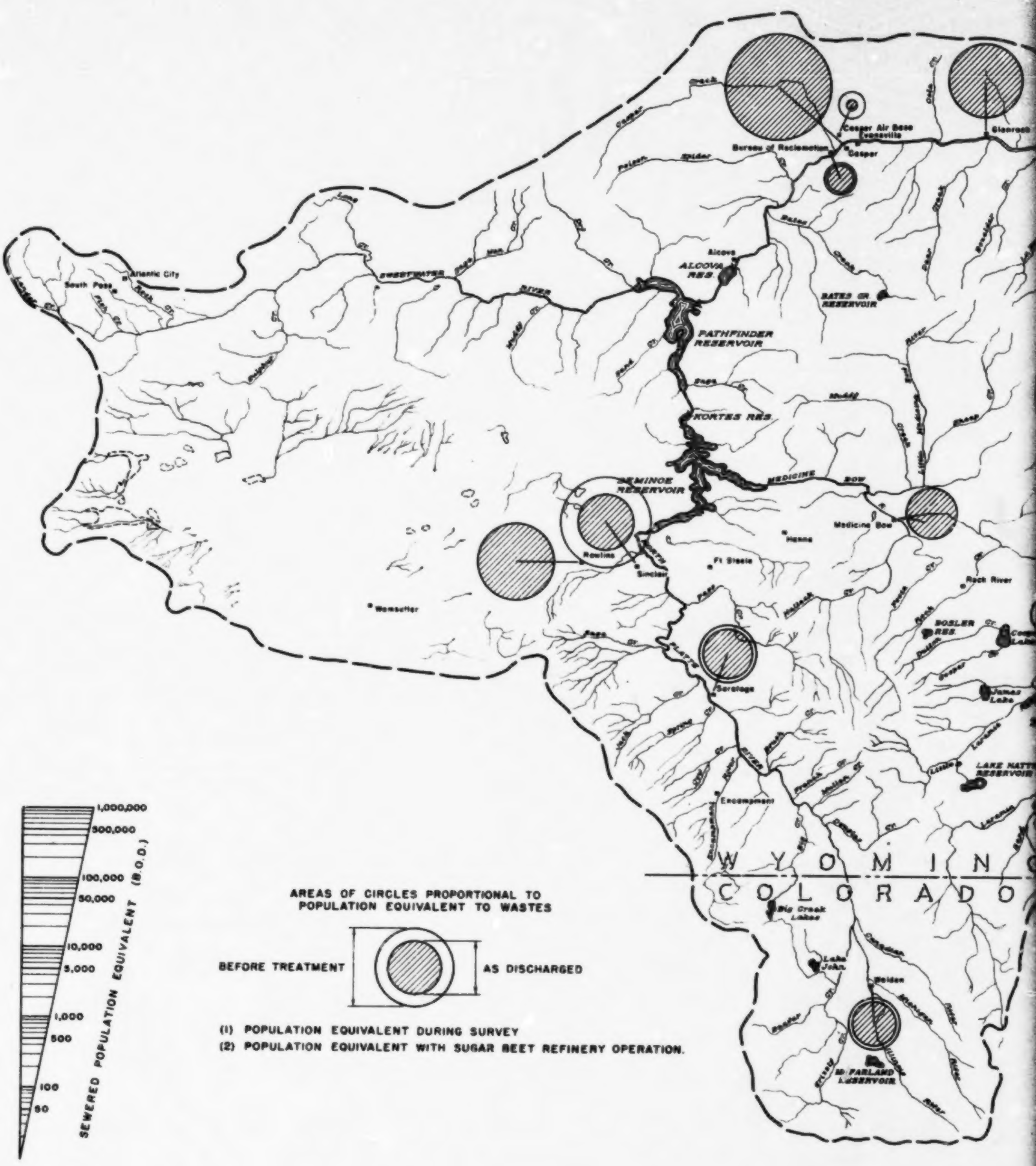


Cars Loaded with Sugar Beets

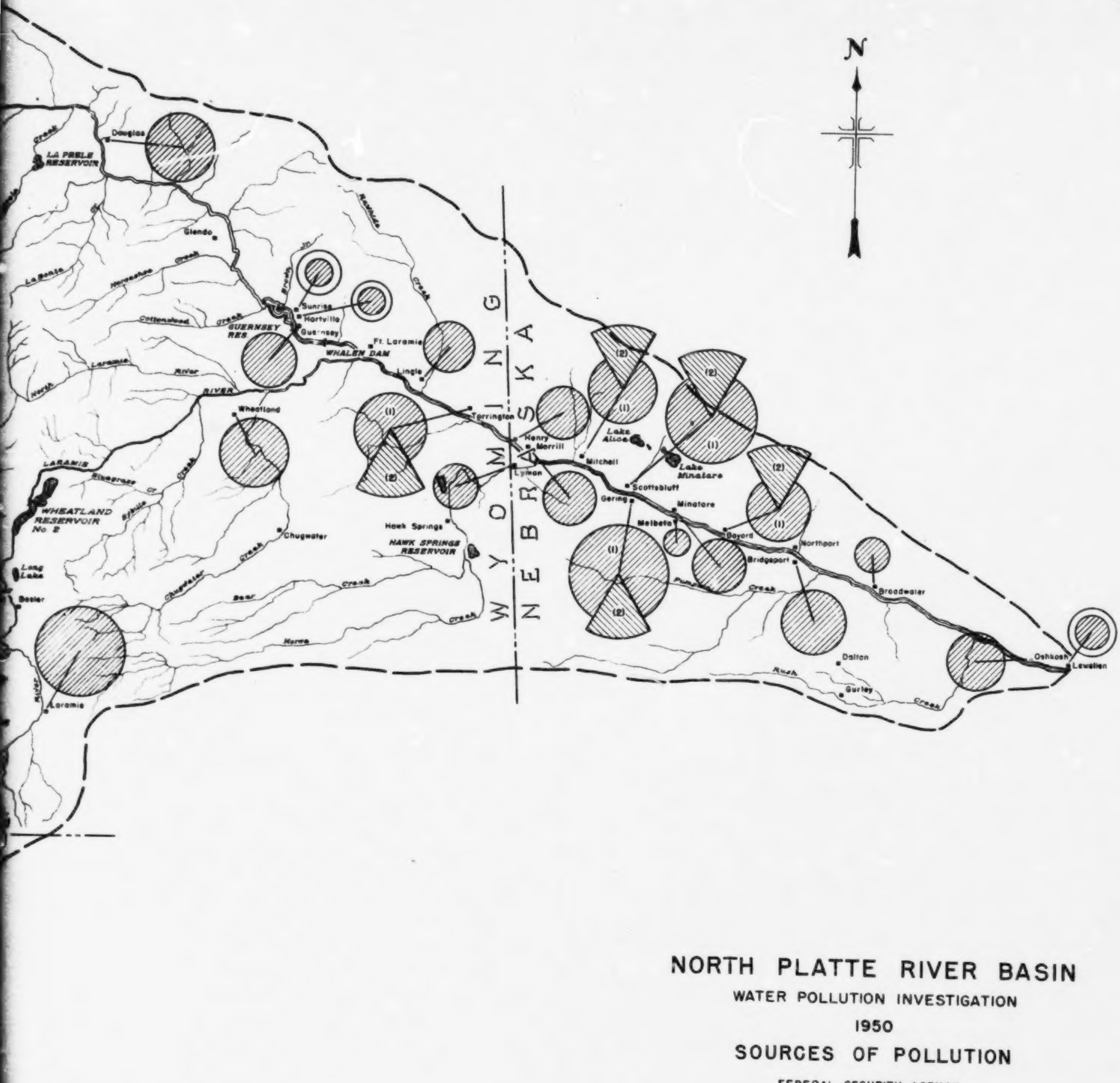
Sugar Beets Piled in Field



Oil Refinery, Casper, Wyoming


Casper Air Base
Evansville
Bureau of Reclamation
Casper
Glenrock
Casper Creek
Poison Spider Cr.
Alcova
ALCOVA RES.
BATES CR. RESERVOIR
Atlantic City
South Pass
SWEETWATER RIVER
PATHFINDER RESERVOIR
KORTES RES.
SEMINOE RESERVOIR
MEDICINE BOW
Medicine Bow
Hanna
Ft Steele
Rawlins
Sinclair
Wamsutter
Rock River
BOSLER RES.
James Lake
LAKE HATTIE RESERVOIR
Saratoga
Encampment
PLATTE RIVER
WYOMING
COLORADO
Big Creek Lakes
Lake John
Walden
McFARLAND RESERVOIR
1,000,000
500,000
100,000
50,000
10,000
5,000
1,000
500
100
50
SEWERED POPULATION EQUIVALENT (B.O.D.)
AREAS OF CIRCLES PROPORTIONAL TO POPULATION EQUIVALENT TO WASTES
BEFORE TREATMENT
AS DISCHARGED
(1) POPULATION EQUIVALENT DURING SURVEY
(2) POPULATION EQUIVALENT WITH SUGAR BEET REFINERY OPERATION.

A


N
Douglas
LA PRELE RESERVOIR
Creek
Glendo
La Bonte
Horseshoe
Creek
Cottonwood
Creek
Sunrise
Hartville
Guernsey
GUERNSEY RES.
WHALEN DAM
Ft. Laramie
Lingle
Laramie
River
North
RIVER
Wheatland
Torrington
(1)
(2)
LARAMIE
Sybille
Cr
Creek
WHEATLAND RESERVOIR No. 2
Chugwater
Hawk Springs
HAWK SPRINGS RESERVOIR
Long Lake
Bosler
Chugwater
Bear
Creek
Horse
Creek
River
Laramie
WYOMING
NEBRASKA
Henry
Morrill
Lyman
Mitchell
Lake Alice
Lake Minatare
Scottsbluff
Gering
Minatare
Melbeta
Bayard
Northport
Bridgeport
Pumpkin
Creek
Broadwater
Dalton
Rush
Gurley
Creek
Oshkosh
Lewellen

NORTH PLATTE RIVER BASIN

WATER POLLUTION INVESTIGATION

1950

SOURCES OF POLLUTION

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
DIVISION OF WATER POLLUTION CONTROL

10 0 10 20 30
SCALE OF MILES

B

52-A

~~Table 8. North Platte River Basin~~ - Sources of Pollution including industrial wastes expressed as severed population equivalent (B.O.D.)

Municipality[1]	State	Miles above mouth North Platte River	Miles above mouth Tributary	Industrial Wastes Population Equivalent (B.O.D.)	Population connected to sewers	Treatment[a]	Severed population equivalent (B.O.D.) Untreated	Severed population equivalent (B.O.D.) Discharged
North Platte River								
Michigan River		680						
Walden	Colo		10		680	P	680	340
Saratoga	Wyo.	579		-	900	P	900	585
Sugar Creek		530						
Rawlins	Wyo.		14	-	6,000	N	6,000	6,000
Sinclair	Wyo.		8	12,000[f]	850	P	12,850	550[f]
Medicine Bow River		495						
Medicine Bow	Wyo.		79	-	450	N	450	450
Mills	Wyo.	399		-	120	P	120	80
Casper Creek		399						
Casper Air Base	Wyo.		8	-	50	S	50	15
Casper	Wyo.	396		60,000	25,000	N	85,000	85,000
Glenrock	Wyo.	366		6,000	1,250	N	7,250	7,250
Douglas	Wyo.	325		-	2,600	N	2,600	2,600
Dry Creek		250						
Sunrise	Wyo.		4	-	330	S	330	75
Hartville	Wyo.		4	-	250	S	250	90
Guernsey	Wyo.	250		-	700	N	700	700
Laramie River		232						
Laramie	Wyo.		135		14,000	P	14,000	14,000[e]
Rock Creek			27					
Wheatland	Wyo.		9		2,500	N	2,500	2,500
Rawhide Creek 3		217						
Lingle ✓	Wyo.		3		550	N	550	550
Torrington 2	Wyo.	209		550,000[b]	3,500	N	3,500[c]	3,500[c]
Henry 2	Nebr.	199		720	75	N	795	795
Horse Creek 3		194						
Lyman ✓	Nebr.		5		350	N	350	350
Morrill 2	Nebr.	191		240	600	N	840	840
Mitchell 2	Nebr.	184		800-170,000[b]	1,800	N	2,600[c]	2,600[c]
Scottsbluff 2	Nebr.	174		8,720-650,000[b]	9,000	N	17,720[c]	17,720[c]
Gering 2	Nebr.	173		33,120-300,000[b]	2,000	ST	35,120[c]	34,400[c]
Minatare 2	Nebr.	166		-	800	N	800	800
Melbeta 2	Nebr.	166		-	75	ST	75	75[d]
Bayard Canal 3		149.5						
Bayard ✓	Nebr.		5	170,000[b]	1,700	N	1,700[c]	1,700[c]
Bridgeport 2	Nebr.	142		1,390	1,000	N	2,390	2,390
Broadwater 2	Nebr.	127			150	N	150	150
Lost Creek 3		95						
Oshkosh ✓	Nebr.		1	330	700	N	1,030	1,030
Lewellen 2	Nebr.	84		-	300	S	300	80
TOTALS				123,320-1,840,000[b]	78,280		201,600[c]	187,215[c]

Copy foot notes (b) & (f)
& a & c

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a. Treatment - N - None
P - Primary
S - Secondary
ST - Septic Tank

b. Seasonal beet sugar wastes

c. Not including seasonal wastes

d. Treatment plant by-passed

e. Plant inadequate - at frequent intervals, no effective removal results

f. Industrial wastes lagooned - do not reach river

1. Industrial outlets are listed in tables I and II, appendix D

refineries are passed through gravity oil separators to remove some of the oil. Based upon biochemical oxygen demand, the industries place a burden upon the North Platte River during the beet campaign equivalent to a population of approximately 1,950,000 persons. Thirty-two percent of this pollution is contributed in Wyoming and 68 percent in Nebraska.

The larger industries discharge wastes to the stream through one or several industrial outlets. These plants and evaluation of their wastes are presented in detail in table I of appendix D.

Low Flow Frequencies

Frequencies of low mean monthly stream flows for the summer (June-September, inclusive), and winter (December-January, inclusive), have been studied. Minimum mean flows, as well as the mean minimum expected discharges in 2, 3, 5 and 10 years, are reported in tables 9 and 10.

Critical pollution effects are normally more pronounced during periods of low flows, and sewage treatment must be based upon the preclusion of detrimental stream conditions over reasonable lengths of time. Where development programs depend upon impoundment and diversion structures for correct provision and routing of conserved waters, it is necessary to consider the stream regimen in order to maintain stream sanitation. Usually summer conditions are critical. High temperatures increase biological activity and reduce saturation limits of oxygen in water. Greater dilution is then necessary for the maintenance of satisfactory stream conditions. During the winter period lower temperatures, reduced biological activity, and higher oxygen levels, coupled with a reduction in the use of water, result in less critical situations. Where streams are frozen over with solid ice cover which prevents reaeration of the stream, oxygen depressions with accompanying nuisance conditions may occur from the oxidation of organic matter contributed by pollution sources.

The present regulation program in the North Platte Basin effects a reversal of the normal situation. During the winter and early spring, stream flows are stored for irrigation and hydroelectric power development and stream discharges are reduced considerably; in the irrigation season, which is initiated in May, the character of the stream is changed from the low-flowing river to a high-velocity, bankfull, watercourse. Releases from Alcova Reservoir to potential Glendo Reservoir at river mile 280.0 would have a leveling effect upon the stream. During the winter period a minimum monthly mean discharge of 820 second-feet is planned; 920 second-feet to occur once in 10 years and 1,000 second-feet to occur once in 5 years. During the summer irrigation season flow of 100 second-feet is planned for minimum, 5, and 10-year monthly mean flows, and 1,300 and 640 second-feet respectively for the 2 and 3-year flows.

Table 9. North Platte River Basin - Frequency of low mean monthly summer (June-Sept.) discharges[a]

Years of Record	Stream and Location	Miles to mouth		Drainage Area Square Miles[a]	Minimum monthly mean flows in cubic feet per second that may be expected once in:				
		North Platte River	Tributary		2 years	3 years	5 years	10 years	Minimum
	North Platte River Basin								
23	Near Walden, Colo.	665		463	38	32	29	20	12
17	Near Northgate, Colo.	651		1,446	82	79	70	43	23
17	Saratoga, Wyo.	579		2,880	200	180	150	110	67
17	Near Sinclair, Wyo.	530			210	180	160	140	66
31	Inflow Seminoe Reservoir	523			320	220	180	170	40
7	Medicine Bow River-10 mi. N. of Hanna, Wyo.	495			10.5	10	9	7	6
17	Outflow Seminoe Reservoir	482			280	220	220	70	40
17	Inflow Pathfinder Reservoir	466		8,524	390	270	210	130	97
17	Outflow Pathfinder Reservoir	452			700	500	370	120	82
9	Inflow Alcova Reservoir	446			540	520	300	140	130
17	Alcova Reservoir release to North Platte Riv.	442			2,100	1,600	1,400	540	450
9	Below Alcova Reservoir	442		10,800	1,400	1,100	640	340	180
17	Below Casper, Wyo.	392		12,600	1,500	870	640	450	140
17	Douglas, Wyo.	325		14,300	1,600	1,000	790	470	190
17	Inflow Guernsey Reservoir	265			2,000	1,500	1,100	450	260
17	Below Guernsey Reservoir	251		16,200	2,200	1,500	1,200	400	250
17	Below Whalen Dam	243			360	220	150	100	44
17	Below Whalen, Wyo.	242			350	240	140	100	44
10	Laramie River near Ft. Laramie, Wyo.	232	2		35.7	21.0	16.8	13.4	4.1
	Laramie River near Laramie, Wyo.	232	135		10.0	6.4	4.0	2.9	2.6
	Rawhide Creek near Lingle, Wyo.	217			25.2	20.7	15.1	8.4	8.0
17	Wyoming-Nebraska State Line	200			790	700	660	440	160
17	Tri-State Diversion Dam	198			96	30	25	20	19
	Horse Creek near Lyman, Nebr.	194			62.0	50.4	20.5	16.0	6.1
17	Mitchell, Nebr.	184		24,300	260	220	150	90	80
17	Minatare, Nebr.	166			320	280	240	96	28
17	Bridgeport, Nebr.	142		25,300	490	400	320	120	85
15	Lisco, Nebr.	113		26,900	440	360	310	120	87
17	Oshkosh, Nebr.	96		27,500	420	330	270	100	17
17	Alcova Reservoir Routing[b]	442			1,300	640	100	100	100
17	Glendo Storage[b]	280			1,000	1,000	1,000	1,000	1,000

Table 10. North Platte River Basin - Frequency of low mean monthly winter (Dec.-Feb.) discharges[a]

Years of Record	Stream and Location	Miles to mouth		Drainage Area Square Miles[a]	Minimum monthly mean flows in cubic feet per second that may be expected once in:				
		North Platte River	Tributary		2 years	3 years	5 years	10 years	Minimum
	North Platte River Basin								
2	Near Walden, Colo.	665		463	Two year record inadequate				
17	Near Northgate, Colo.	651		1,446	57	47	40	35	33
17	Saratoga, Wyo.	579		2,880	230	200	190	170	130
17	Near Sinclair, Wyo.	530			240	220	210	180	140
31	Inflow Seminoe Reservoir	523			310	280	230	220	190
7	Medicine Bow River-10 mi. N. of Hanna, Wyo.	495			24	20	16	13	12
17	Outflow Seminoe Reservoir	482			270	250	220	200	180
17	Inflow Pathfinder Reservoir	466		8,524	350	310	280	230	210
17	Outflow Pathfinder Reservoir	452			25	0	0	0	0
8	Inflow Alcova Reservoir	446			13	8.4	3.3	1.7	0
	Alcova Reservoir release to North Platte Riv.	442			No release in winter				
8	Below Alcova Reservoir	442		10,800	3.3	3.3	0.3	0	0
7	Below Casper, Wyo.	392		12,600	70	65	60	55	50
7	Douglas, Wyo.	325		14,300	120	110	110	100	80
17	Inflow Guernsey Reservoir	265			180	160	130	120	120
17	Below Guernsey Reservoir	251		16,200	190	150	120	90	25
17	Below Whalen Dam	243			35	17	10	5.0	1.7
17	Below Whalen, Wyo.	242			34	12	6.7	5.0	1.7
10	Laramie River near Ft. Laramie, Wyo.	232	2		14.1	8.7	6.4	6.4	6.1
	Laramie River near Laramie, Wyo.	232	135		No record				
	Rawhide Creek near Lingle, Wyo.	217			14.6	12.9	9.3	8.3	7.7
17	Wyoming-Nebraska State Line	200			410	350	330	280	280
17	Tri-State Diversion Dam	198			400	350	320	280	270
	Horse Creek near Lyman, Nebr.	194			18.2	16.4	15.8	12.3	7.6
17	Mitchell, Nebr.	184		24,300	590	530	450	430	420
17	Minatare, Nebr.	166			800	770	610	590	540
17	Bridgeport, Nebr.	142		25,300	1,040	990	810	760	750
15	Lisco, Nebr.	113		26,900	1,200	1,000	940	860	840
17	Oshkosh, Nebr.	96		27,500	1,300	1,100	1,100	930	910
17	Alcova Reservoir Routing[b]	442			1,000	1,000	1,000	920	820
17	Glendo Storage[b]	280			4,300	4,300	4,300	4,300	4,200

---

[a] Based on data obtained from Bureau of Reclamation.

[b] Based upon proposed Glendo Reservoir Operation - tentative basin studies not yet completed which would supplant these figures indicate a minimum flow of 500 c.f.s. between Bessemer Bend and Glendo.

Recent information from the Bureau of Reclamation indicates that a Basin operation study, which is incomplete at this time, shows that a minimum flow of 500 c.f.s. between Bessemer Bend and Glendo may be maintained. This plan, if developed, will necessitate revisions of portions of this report.

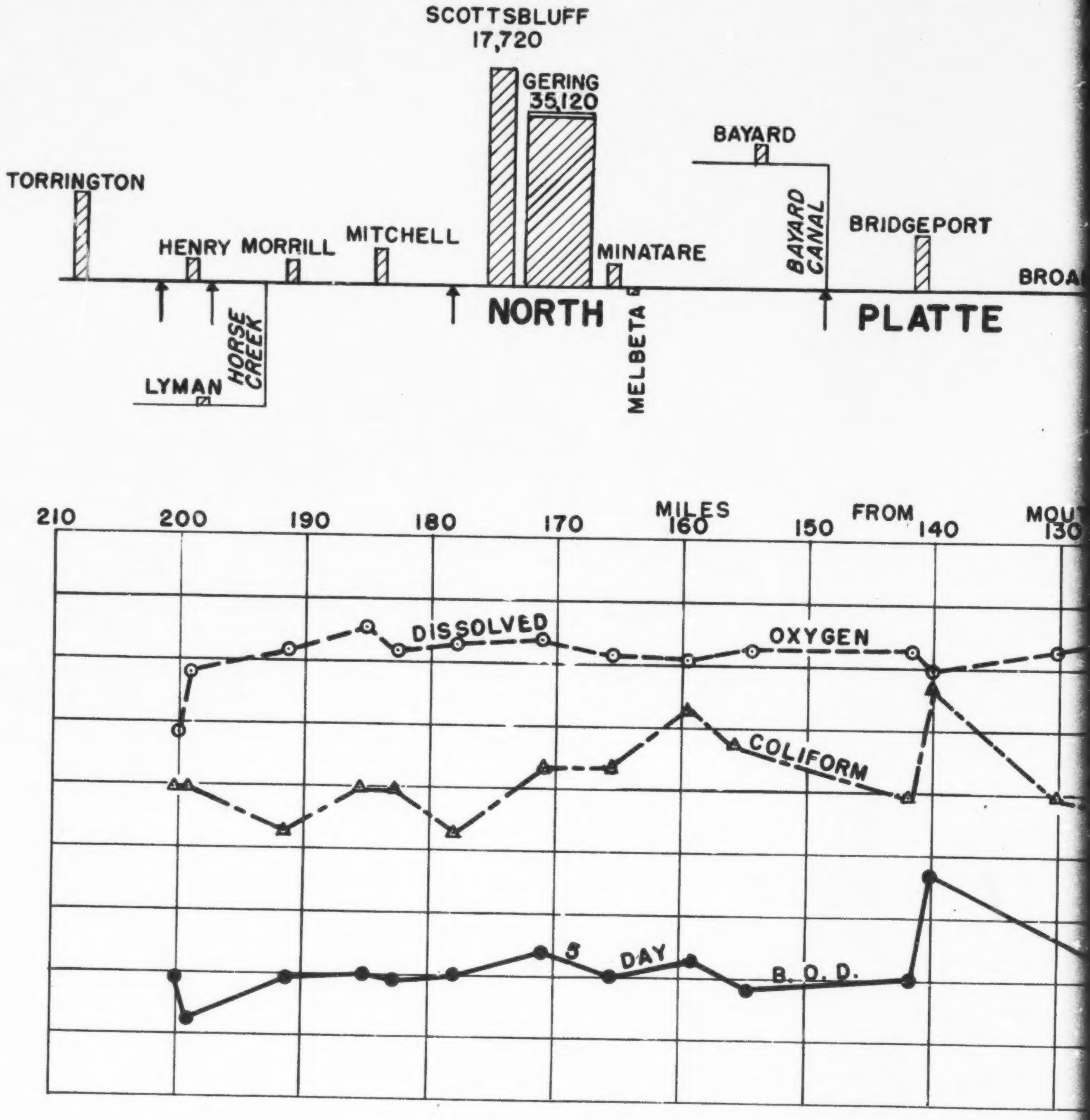
Laboratory Results

The characteristics of the pollutional load contributed to the North Platte River made it essential that stream sampling be conducted during various seasons of the year so as to secure laboratory data representative of the varying situations that develop. Average laboratory data and sources of pollution expressed in population equivalents and located by river miles are depicted graphically as figures 6, 7, and 8. Major dams and diversionary structures are also shown in the above figures. Summations of average laboratory data are presented in figures 9, 10, and 11. A summery of individual laboratory results is included as appendix F.

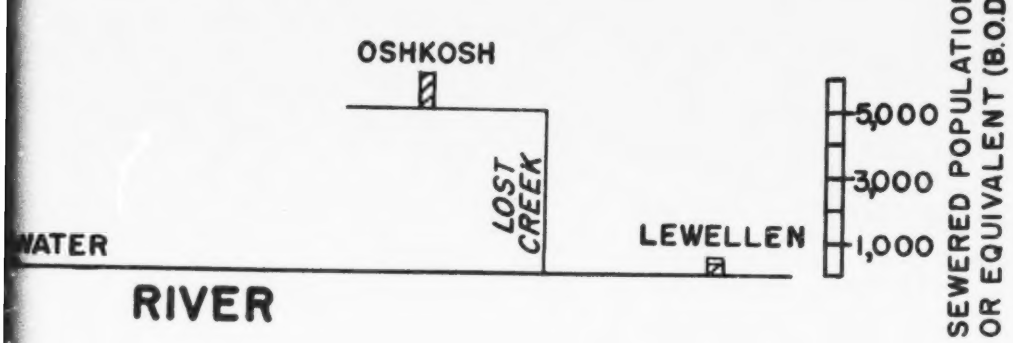
To facilitate presentation and to more accurately show stream conditions, the data were divided into two parts. One section, Casper to Guernsey Reservoir, reflects industrial pollution while the section from Torrington to Lake McConaughy shows the results of the seasonal beet sugar refinery operations as compared to summer conditions.

The June 1949 results showing conditions from Torrington to Lake McConaughy are portrayed in figure 6. Laboratory data reflect the high water stages encountered during the sampling period. In the vicinity of Henry, Nebraska, the dissolved oxygen rose from a minimum of 5.8 p.p.m. to about 7.0 p.p.m. The dissolved oxygen showed a maximum of 7.8 p.p.m. near Lewellen, Nebraska. A maximum mean coliform count of 67,000 per 100 ml. was obtained near Bridgeport. Generally the mean coliform results showed moderate pollution values varying from 5,000 to 10,000 per 100 ml. Below Minatare a count of 46,000 per 100 ml. may have been the effect of organic pollution entering at Gering and Scottsbluff. The smaller the number of coliforms the more suitable are the waters for a water supply. The data indicate that the water in this reach of the North Platte River, containing from 5,000 to 20,000 coliforms per 100 milliliters, would generally be unsatisfactory for ordinary filtration treatment. The maximum B.O.D. of 3.7 p.p.m. at Bridgeport (figure 6) indicated light to moderate pollution. Below Bridgeport decreases in B.O.D. were accompanied by a decrease in median coliform count and a slight increase in dissolved oxygen content. This indicates that only slight pollution was present in the lower reaches.

Average results of the laboratory study during November 1950 in the river section Torrington, Wyoming to Lake McConaughy are presented in figure 7. These data reflect the pollutional discharges of the seasonally operated beet sugar refineries. The dissolved oxygen


SCOTTSBLUFF
17,720
GERING
35,120
BAYARD
TORRINGTON
BAYARD CANAL
BRIDGEPORT
HENRY
MORRILL
MITCHELL
MINATARE
BROA
NORTH
PLATTE
MELBETA
HORSE CREEK
LYMAN
210
200
190
180
170
MILES
160
150
FROM
140
MOUT
130
DISSOLVED
OXYGEN
COLIFORM
5
DAY
B. O. D.

A


OSHKOSH
LOST CREEK
WATER
LEWELLEN
RIVER
5,000
3,000
1,000
SEWERED POPULATION OR EQUIVALENT (B.O.D.)

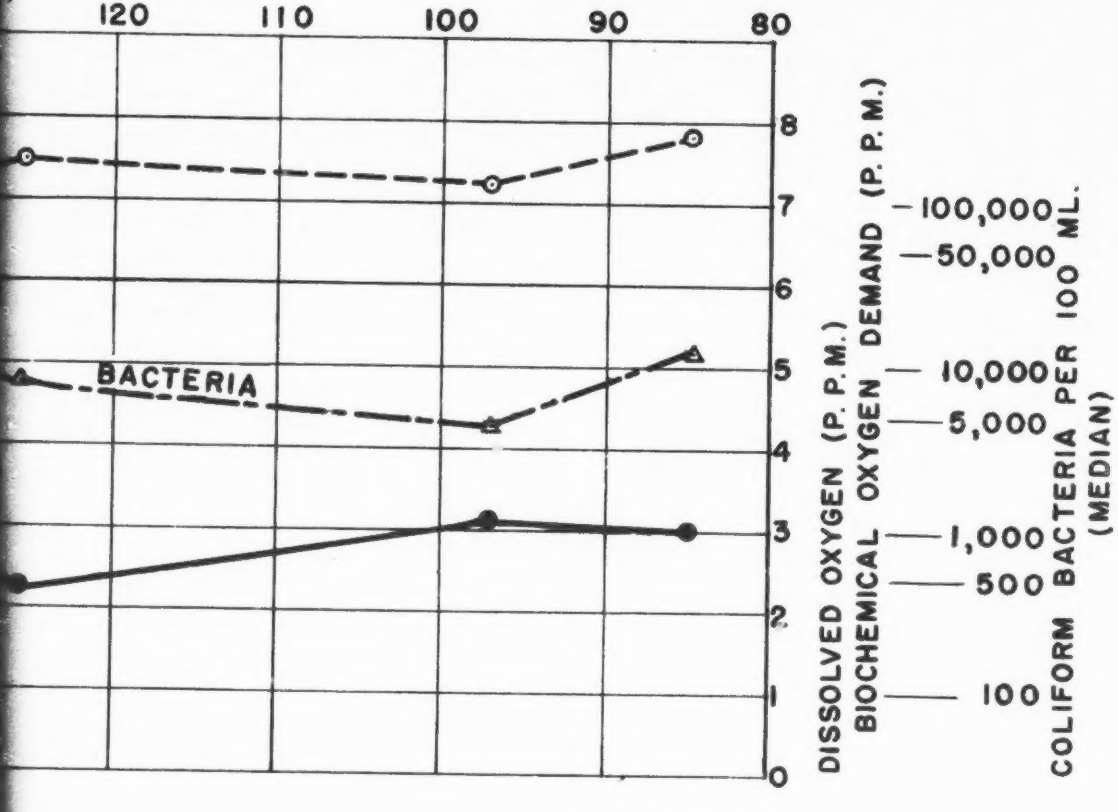

120
110
100
90
80
8
7
6
5
4
3
2
1
0
BACTERIA
100,000
50,000
10,000
5,000
1,000
500
100
DISSOLVED OXYGEN (P. P. M.)
BIOCHEMICAL OXYGEN DEMAND (P. P. M.)
COLIFORM BACTERIA PER 100 ML. (MEDIAN)

FIGURE 6

☐ POLLUTION REMOVED BY TREATMENT

▨ POLLUTION DISCHARGED

↑ DIVERSION DAM

NORTH PLATTE RIVER BASIN
SOURCES OF POLLUTION
AND
AVERAGE LABORATORY RESULTS
(TORRINGTON WYO, TO LEWELLEN NEBR.)

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
DIVISION OF WATER POLLUTION CONTROL
JUNE 1949

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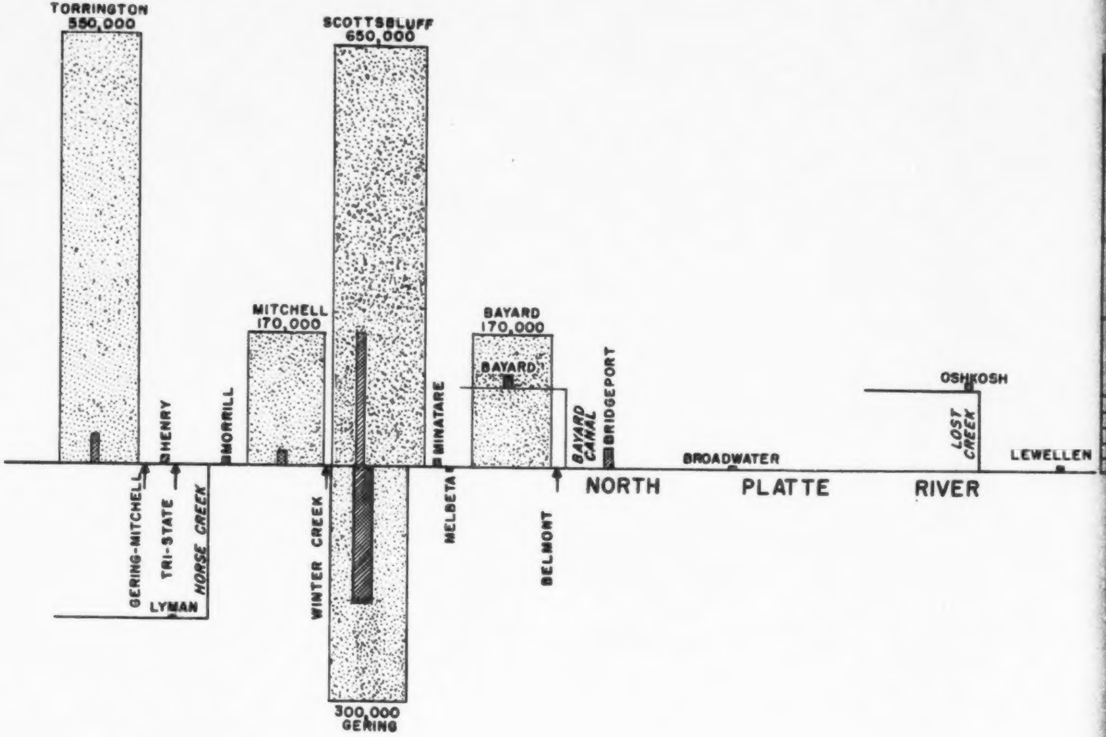
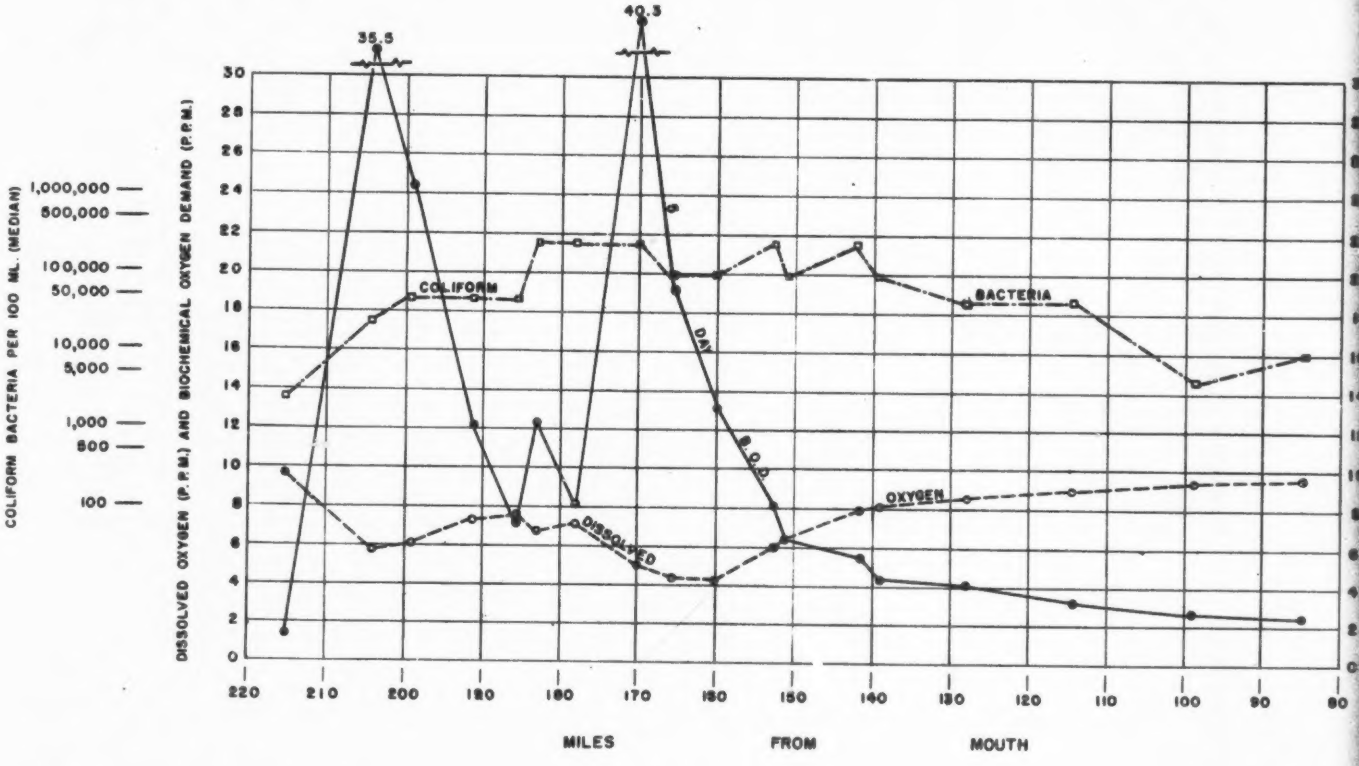
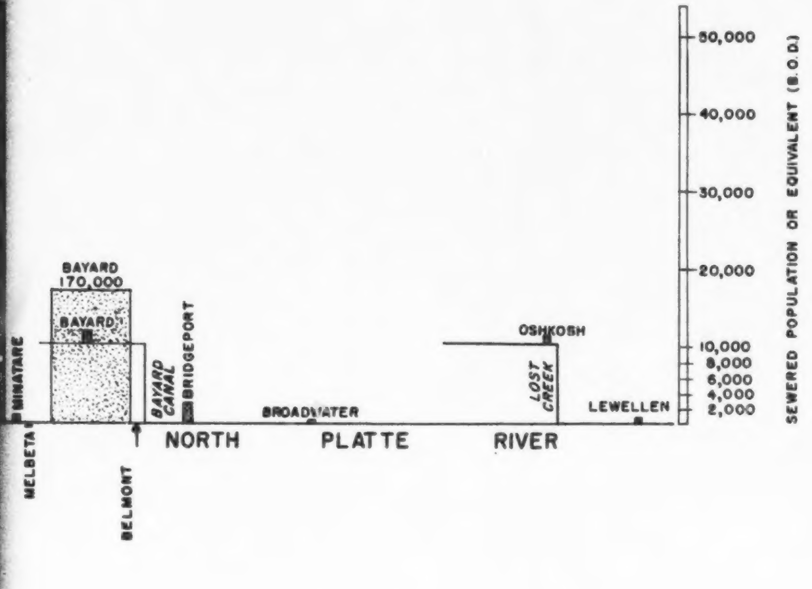

TORRINGTON
550,000
SCOTTSBLUFF
650,000
MITCHELL
170,000
BAYARD
170,000
BAYARD
HENRY
MORRILL
MINATARE
BRIDGEPORT
BAYARD CANAL
BROADWATER
OSHKOSH
LOST CREEK
LEWELLEN
NORTH
PLATTE
RIVER
GERING-MITCHELL
TRI-STATE
HORSE CREEK
LYMAN
WINTER CREEK
MELBETA
BELMONT
300,000
GERING


35.5
40.3
COLIFORM BACTERIA PER 100 ML. (MEDIAN)
1,000,000
500,000
100,000
50,000
10,000
5,000
1,000
500
100
DISSOLVED OXYGEN (P.P.M.) AND BIOCHEMICAL OXYGEN DEMAND (P.P.M.)
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
COLIFORM
BACTERIA
5 DAY
B.O.D.
DISSOLVED
OXYGEN
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
MILES
FROM
MOUTH

4



MUNICIPAL WASTE (EXCLUDING SEASONAL WASTES) DISCHARGED

☐ POLLUTION REMOVED BY TREATMENT.

▨ POLLUTION DISCHARGED

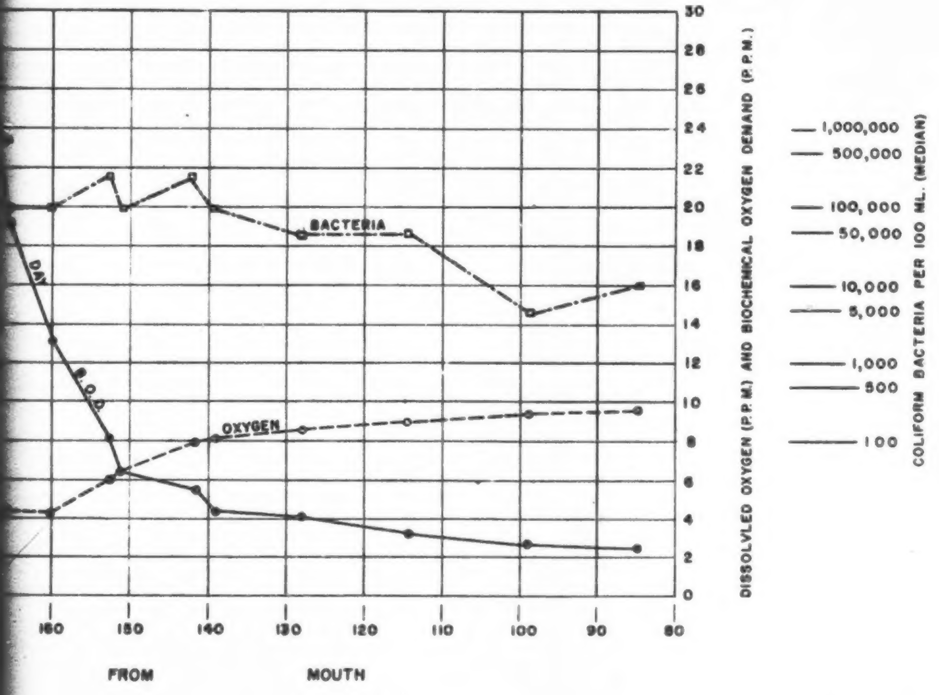
SEASONAL WASTES DISCHARGED

▨ SUGAR-BEET REFINERY WASTES DISCHARGED

△ MAJOR DAMS (PROPOSED)

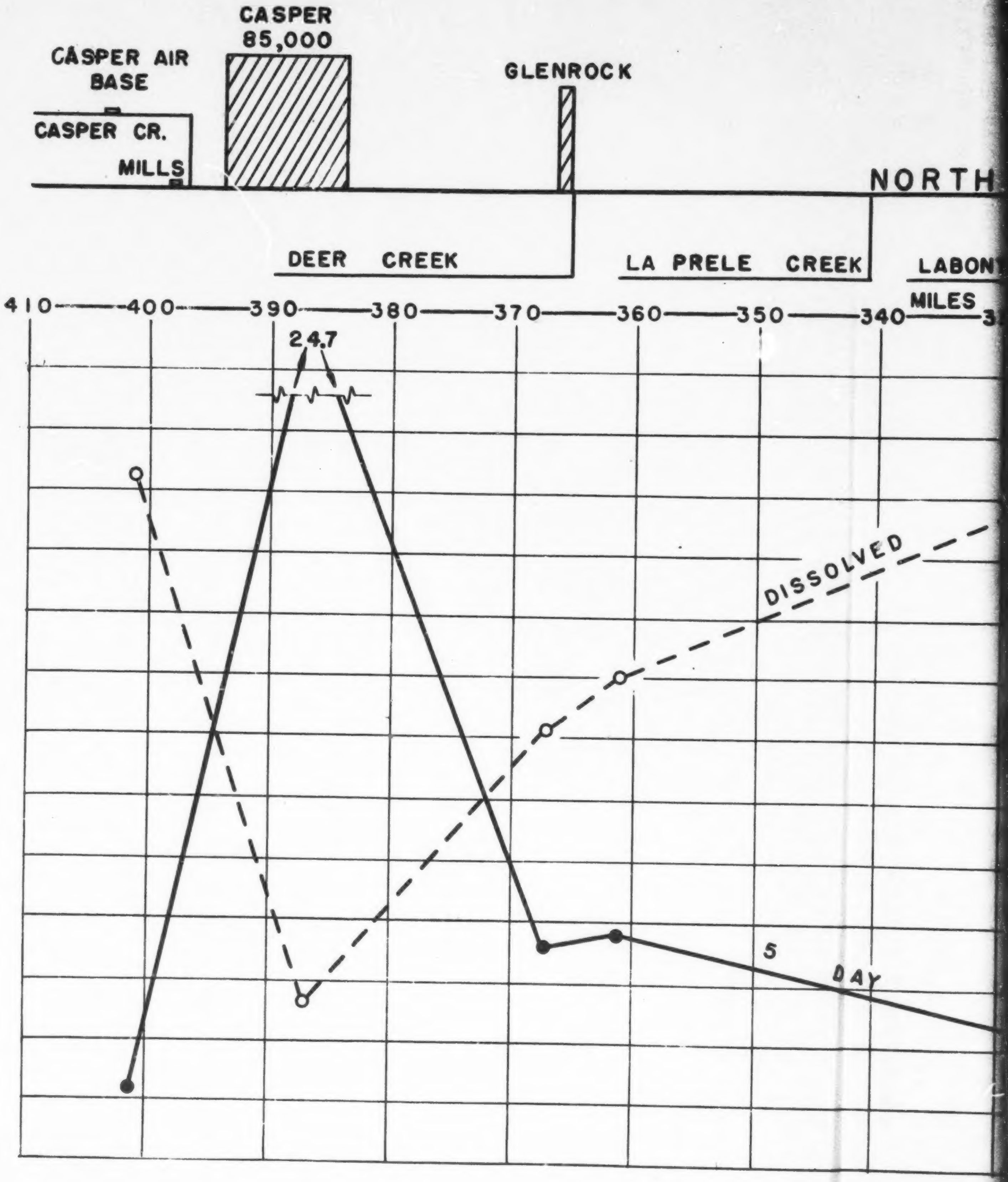
▲ MAJOR DAMS (EXISTING)

↑ DIVERSION DAM (EXISTING)

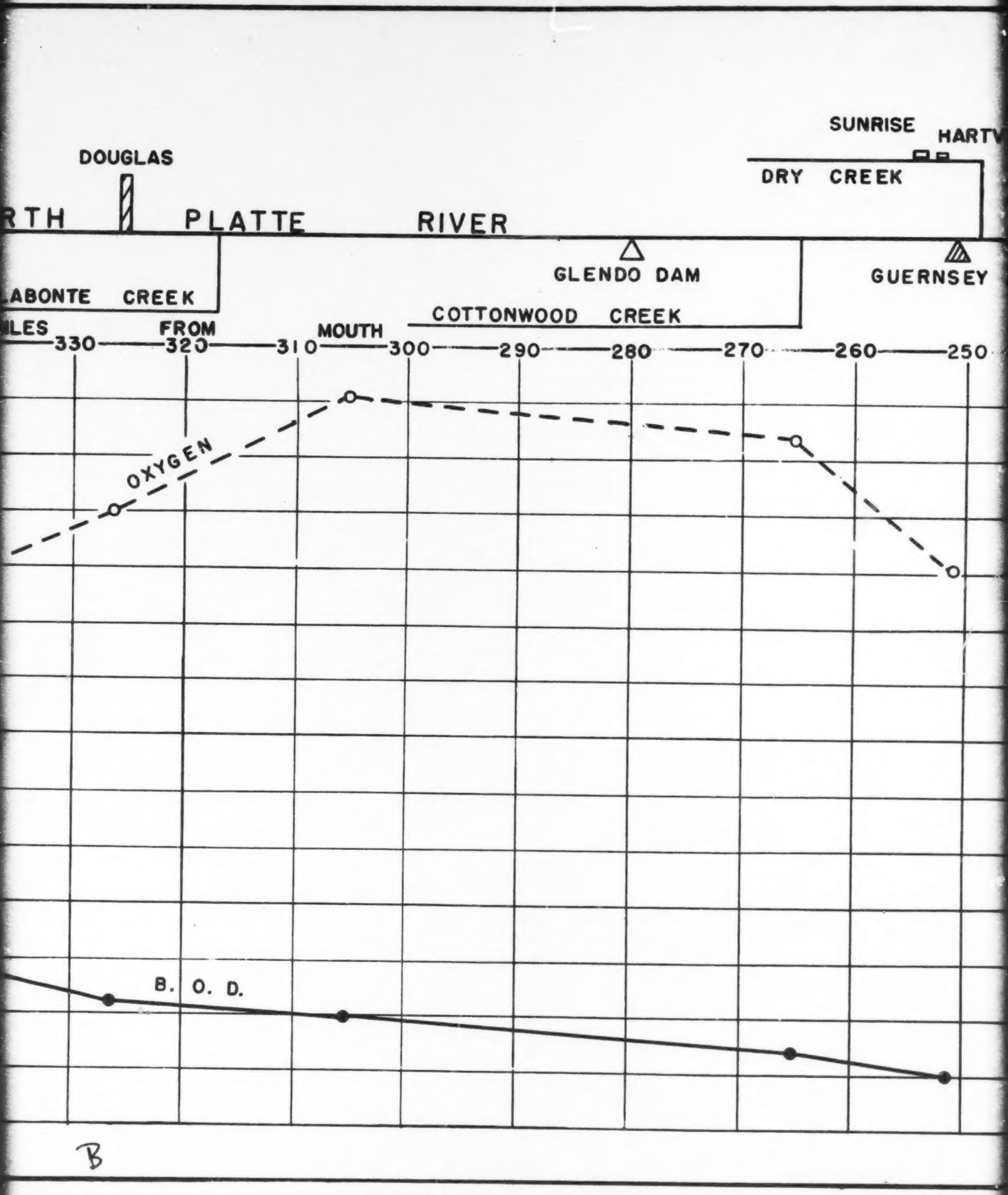


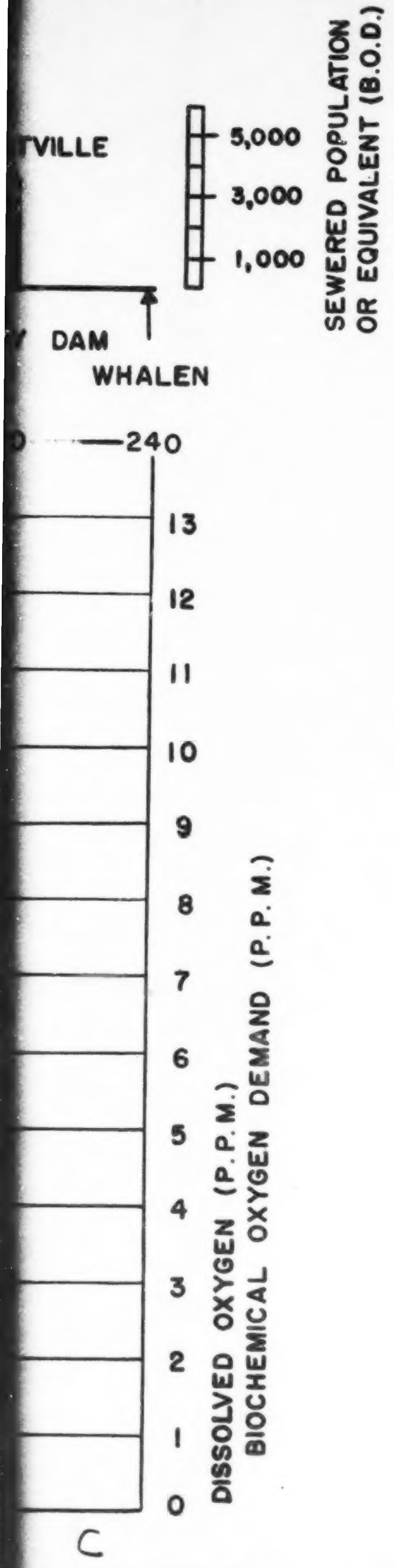
NORTH PLATTE RIVER BASIN
SOURCES OF POLLUTION
AND
AVERAGE LABORATORY RESULTS
(TORRINGTON, WYO. TO LEWELLEN, NEBR.)
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
DIVISION OF WATER POLLUTION CONTROL
NOVEMBER 1950

B


CASPER AIR BASE
CASPER 85,000
GLENROCK
CASPER CR.
MILLS
NORTH
DEER CREEK
LA PRELE CREEK
LABON
MILES
410
400
390
380
370
360
350
340
24.7
DISSOLVED
5 DAY

A


DOUGLAS
SUNRISE
HARTV
DRY CREEK
RTH PLATTE RIVER
GLENDO DAM
GUERNSEY
LABONTE CREEK
COTTONWOOD CREEK
LES FROM MOUTH
330
320
310
300
290
280
270
260
250
OXYGEN
B. O. D.
B



▯ POLLUTION REMOVED BY TREATMENT

▨ POLLUTION DISCHARGED

△ MAJOR DAMS (PROPOSED)

▲ MAJOR DAMS EXISTING

↑ DIVERSION DAM

NORTH PLATTE RIVER B

SOURCES OF POLLUTION
AND
AVERAGE LABORATORY RESU

(CASPER TO GUERNSEY RESERVOIR WYO.)

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
DIVISION OF WATER POLLUTION CON
FEBRUARY 1950

FIGURE 8

▯ POLLUTION REMOVED BY TREATMENT

▨ POLLUTION DISCHARGED

△ MAJOR DAMS (PROPOSED)

▲ MAJOR DAMS EXISTING

↑ DIVERSION DAM

NORTH PLATTE RIVER BASIN

SOURCES OF POLLUTION AND AVERAGE LABORATORY RESULTS

(CASPER TO GUERNSEY RESERVOIR WYO.)

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
DIVISION OF WATER POLLUTION CONTROL
FEBRUARY 1950

56-C D

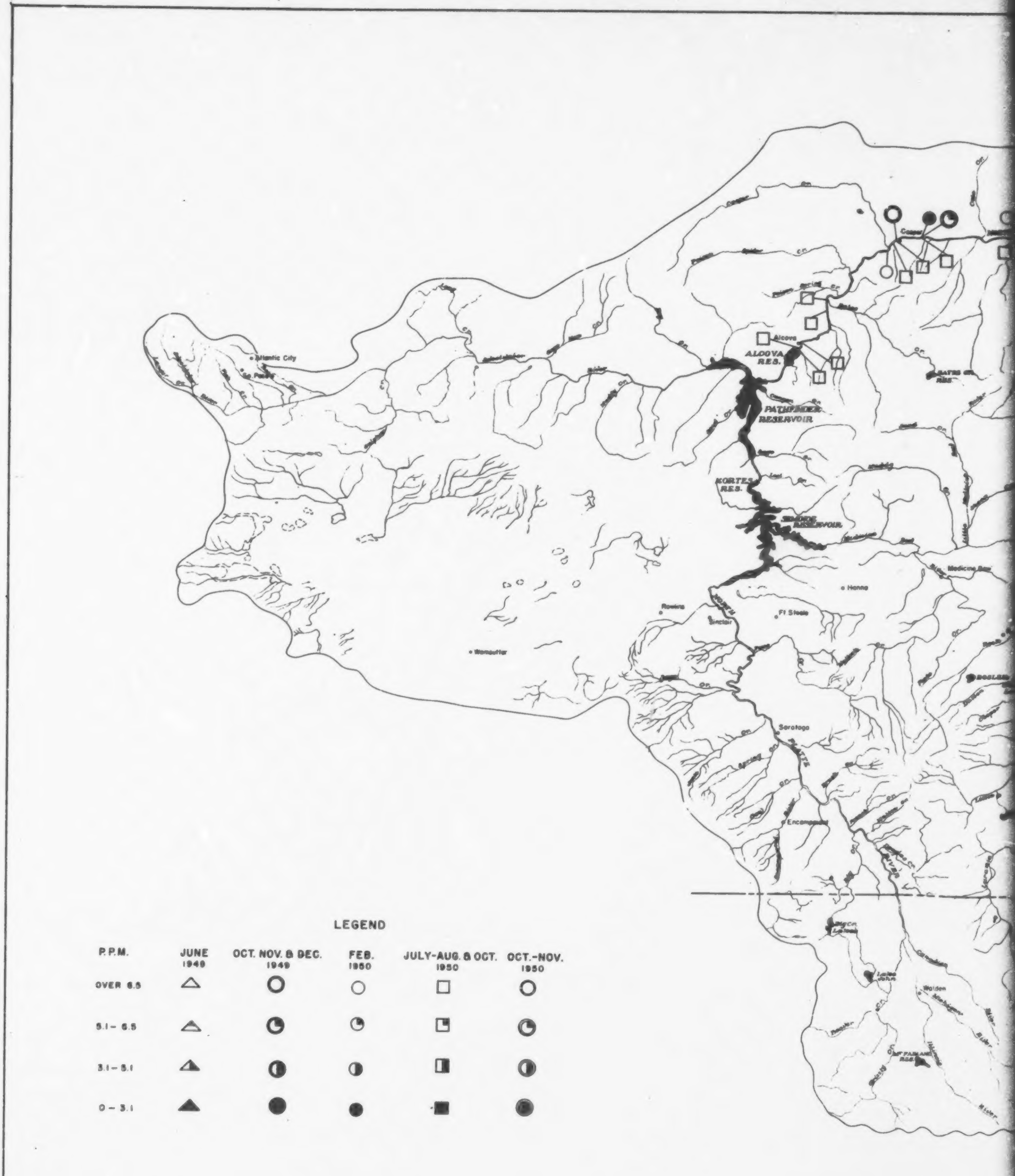
content dropped from 9.8 p.p.m. above Torrington, Wyoming, to 5.7 p.p.m. below the point of pollution discharge. The stream recovered to 7.4 p.p.m. above Mitchell, Nebraska; additional pollution discharged to the stream caused the dissolved oxygen to recede slightly to 6.5 p.p.m. at river mile 183. A dissolved oxygen of 7.0 p.p.m. was recorded for the sampling point above Scottsbluff, Nebraska, and pollution contributed largely by industry caused a rapid drop to 4.3 p.p.m. The dissolved oxygen curve recovered and below Bridgeport, Nebraska, exceeded 8.0 p.p.m. From a B.O.D. of 1.3 p.p.m. above Torrington, Wyoming, (figure 7) the demand increased to 35.5 p.p.m., showing gross pollution, and decreased progressively until additional pollution caused an upswing below Mitchell. Stream recovery resulted in a drop to 8.0 p.p.m. The discharge of pollutional wastes in the Scottsbluff-Gering area resulted in a recorded average high 5-day B.O.D. of 40.3 p.p.m. The precipitous drop due to additional dilution and the self-purification phenomenon gradually leveled off below Broadwater, Nebraska, until a B.O.D. of 2.5 p.p.m. was reached at Lewellen. The stream thus reflects a picture of cleanliness in the reaches immediately above Torrington; gross pollution from Torrington to Bridgeport; moderate pollution below Bridgeport to a point below Broadwater and from that locality light pollution to Lewellen, Nebraska. The same conditions are reflected by the coliform results shown in figure 7. The minimum median coliform count recorded during the survey was for the sampling station above Torrington, Wyoming. Below Torrington, coliform counts of 43,000/100 ml., 93,000/100 ml., and 240,000/100 ml. were recorded. Thus it is apparent that the North Platte River from Torrington downstream has a high bacterial contamination.

The results of sampling the river reach, Casper to Guernsey Reservoir, in the winter period ending February 1950 are presented in figure 8. The dissolved oxygen content, which dropped from 11.3 p.p.m. above Casper to 2.6 p.p.m. below Casper, depicts the oxygen-consuming power of the contributed industrial and domestic wastes. Recovery was rapid until a point near Glenrock was reached where additional pollution reduced the rate of recovery. Near river mile 305 the stream attained a D.O. concentration of 13.1 p.p.m., as a result of stream recovery and reaeration. The effect of pollution is shown also in the B.O.D. curve. From a value of 1.2 p.p.m. above Casper, the biochemical oxygen demand reached 24.7 p.p.m. below Casper and then dropped to 3.6 p.p.m. above Glenrock as a result of stream recovery. The effect of additional pollution discharged to the river at Glenrock is indicated by a slight rise in the B.O.D. curve. The B.O.D. ultimately declined to 1.0 p.p.m. at Guernsey Reservoir.

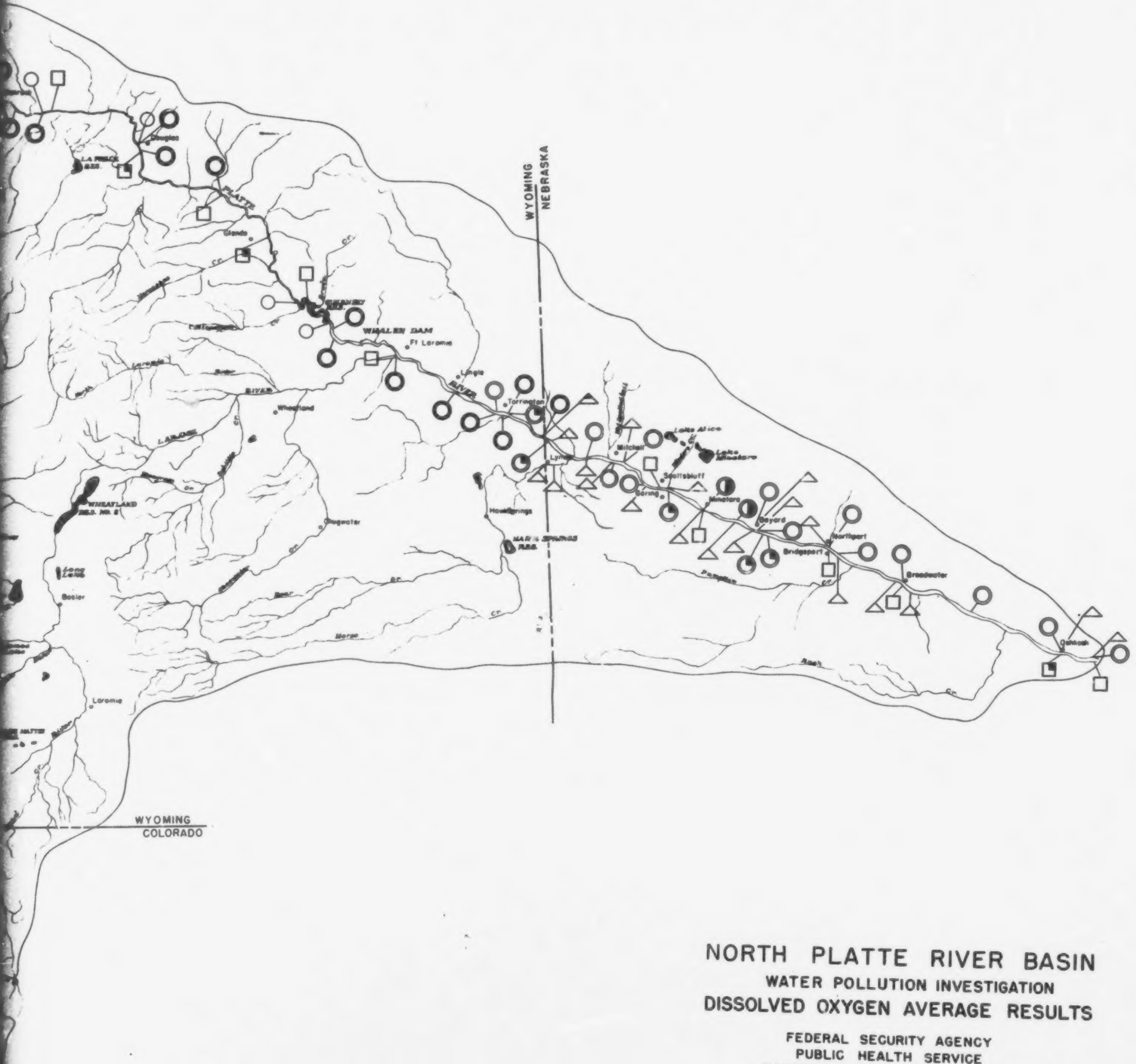
The composite results of the dissolved oxygen data are presented on a map as figure 9, which shows average dissolved oxygen values at various times of the year which correspond to discharge ranges resulting from stream regimen principally for irrigation use. The combination of large pollutional discharges and low flows is detrimental to stream sanitation and critical zones are apparent below major sources of pollution during periods of low flow. This is especially noticeable below Casper and Torrington, Wyoming, and Scottsbluff, Nebraska.

Figure 10 depicts the composite data of the biochemical oxygen demand results. The upper reaches of the North Platte River, in the absence of significant pollution, is a clean stream. Below Casper, Wyoming, the combination of low flow and large municipal and industrial waste discharges increases the B.O.D. beyond 5 p.p.m. and results in a heavily polluted stream. Stream recovery coupled with additional dilution improves the stream until the B.O.D. averages less than 3 p.p.m. at Guernsey Reservoir. The B.O.D. again increases significantly below Torrington, Wyoming, during the fall beet sugar operations, and additional sources of pollution maintain this condition until the phenomenon of recovery exerts its effect in the lower reaches of the river.

The coliform data, one of the more significant indices of domestic pollution, are shown in figure 11. The results, limited to the river reach, Torrington, Wyoming to Lewellen, Nebraska, indicate a heavily polluted stream in the lower river stretch. Obvious pollution at and immediately below Casper made it desirable to omit the coliform examination and to concentrate on those tests which would more closely identify the types of pollution present.


Atlantic City
So. Pass
Casper
Alcova
ALCOVA RES.
PATHFINDER RESERVOIR
KORTES RES.
SEMINOE RESERVOIR
BATES CR. RES.
Medicine Bow
Hanna
Rawlins
Sinclair
Ft Steele
Wamsutter
Saratoga
Encampment
NORTH PLATTE RIVER
Lake John
Walden
Cr.
LEGEND
P.P.M.
JUNE 1949
OCT. NOV. & DEC. 1949
FEB. 1950
JULY-AUG. & OCT. 1950
OCT.-NOV. 1950
OVER 6.5
5.1 – 6.5
3.1 – 5.1
0 – 3.1

A


Douglas
LA PRELE RES.
PLATTE
Glendo
Cr.
GUERNSEY RES.
WHALEN DAM
Ft Laramie
Lingle
RIVER
Torrington
Wheatland
Laramie
Bear
RIVER
LARAMIE
WHEATLAND RES. NO. 2
Chugwater
Cr.
Long Lake
Bosler
Bear
Horse
Cr.
Laramie
WYOMING
NEBRASKA
Hawk Springs
HAWK SPRINGS RES.
Lyman
Mitchell
Lake Alice
Lake Minatare
Scottsbluff
Gering
Minatare
Bayard
Bridgeport
Northport
Pumpkin
Cr.
Broadwater
Rush
Cr.
Oshkosh
WYOMING
COLORADO

NORTH PLATTE RIVER BASIN

WATER POLLUTION INVESTIGATION

DISSOLVED OXYGEN AVERAGE RESULTS

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
DIVISION OF WATER POLLUTION CONTROL

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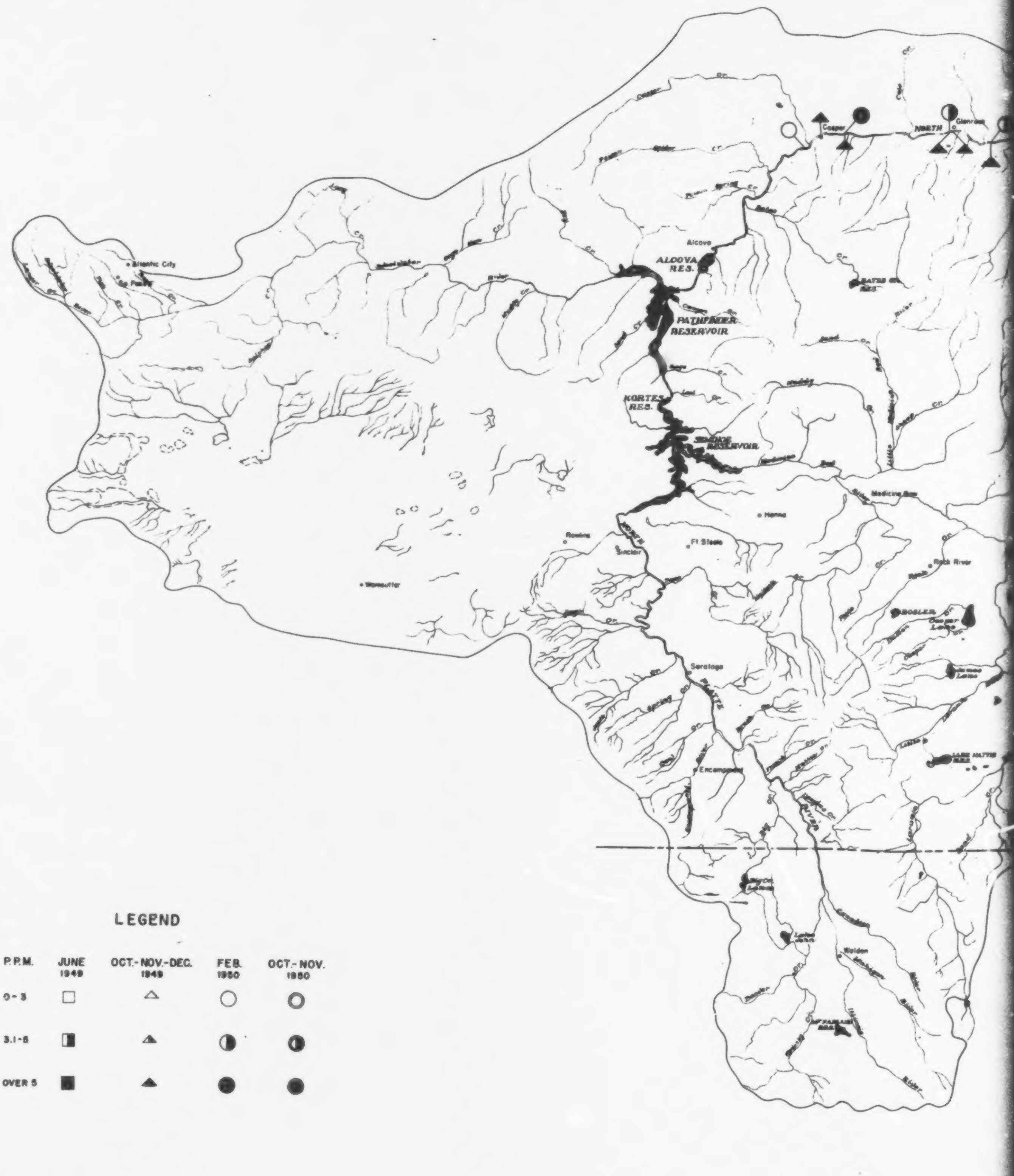
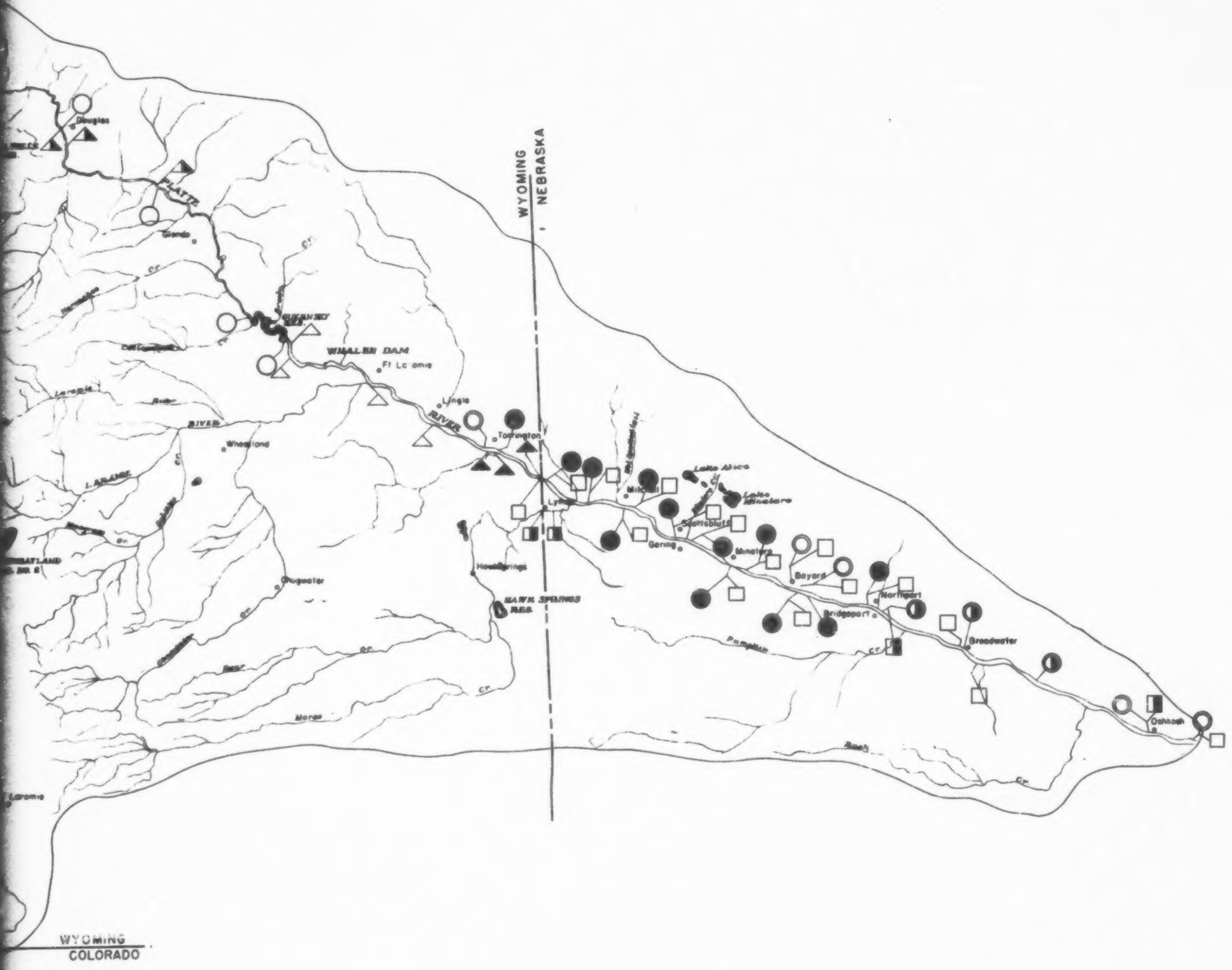
58-A


Casper
NORTH
Glenrock
Alcova
ALCOVA RES.
PATHFINDER RESERVOIR
KORTES RES.
SEMINOE RESERVOIR
Atlantic City
So Pass
Medicine Bow
Hanna
Rawlins
Sinclair
Ft Steele
Rock River
Wamsutter
Saratoga
PLATTE
Encampment
RIVER
Walden
LEGEND
P.P.M.
JUNE 1949
OCT.-NOV.-DEC. 1949
FEB. 1950
OCT.-NOV. 1950
0-3
3.1-5
OVER 5

A


Douglas
PLATTE
Glendo
Cr.
GUERNSEY RES.
WHALEN DAM
Ft Laramie
Laramie
RIVER
Wheatland
L. LARAMIE
WHEATLAND RES. NO. 2
Chugwater
Cr.
Bear
Horse
Lingle
RIVER
Torrington
WYOMING
NEBRASKA
Lyman
Henry
Hawk Springs
HAWK SPRINGS RES.
Mitchell
Lake Alice
Lake Minatare
Scottsbluff
Gering
Minatare
Bayard
Northport
Bridgeport
Pumpkin
Cr.
Broadwater
Oshkosh
Rush
Cr.
Laramie
WYOMING
COLORADO

NORTH PLATTE RIVER BASIN

WATER POLLUTION INVESTIGATION

BIOCHEMICAL OXYGEN DEMAND
AVERAGE RESULTS

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
DIVISION OF WATER POLLUTION CONTROL

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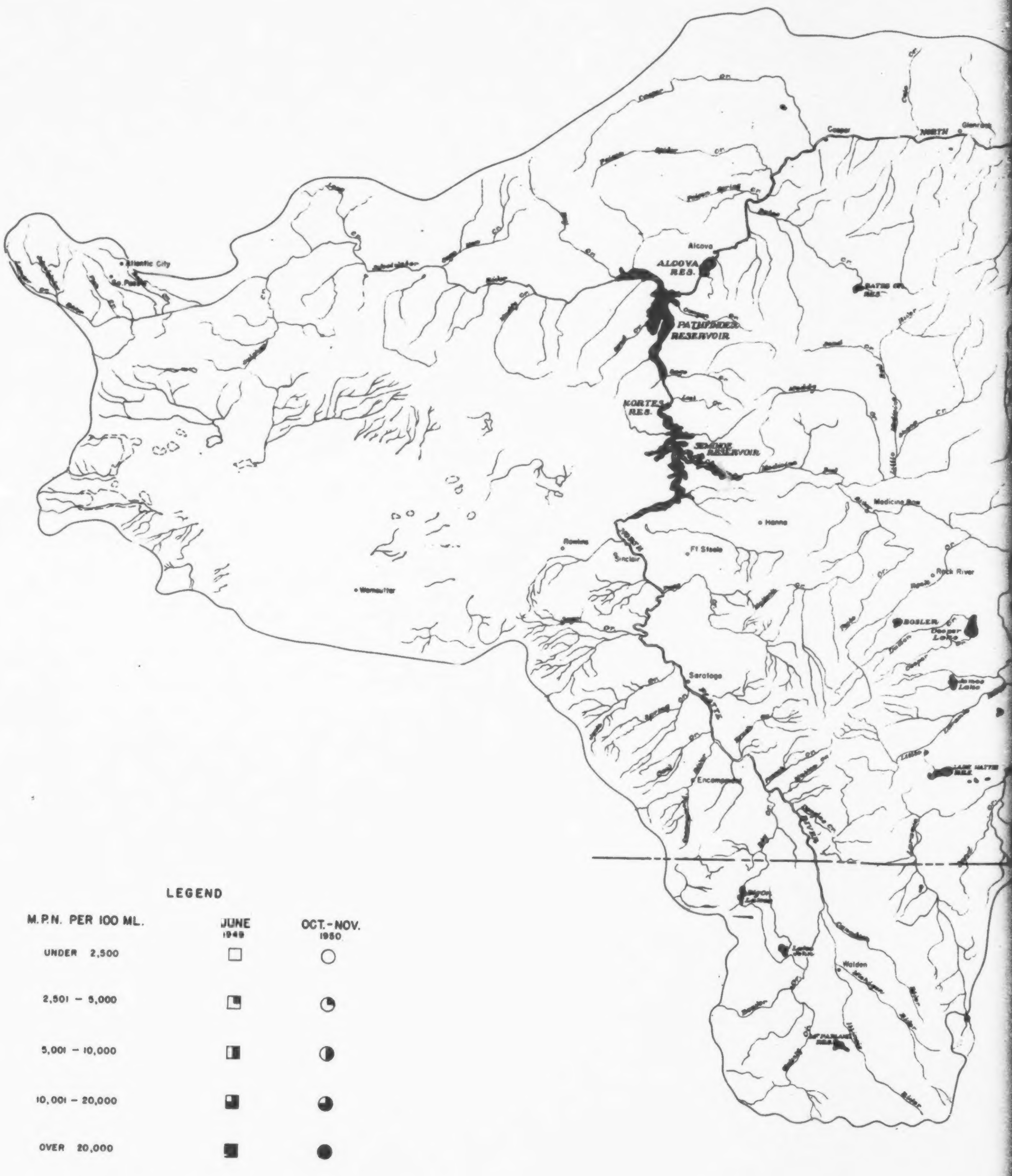
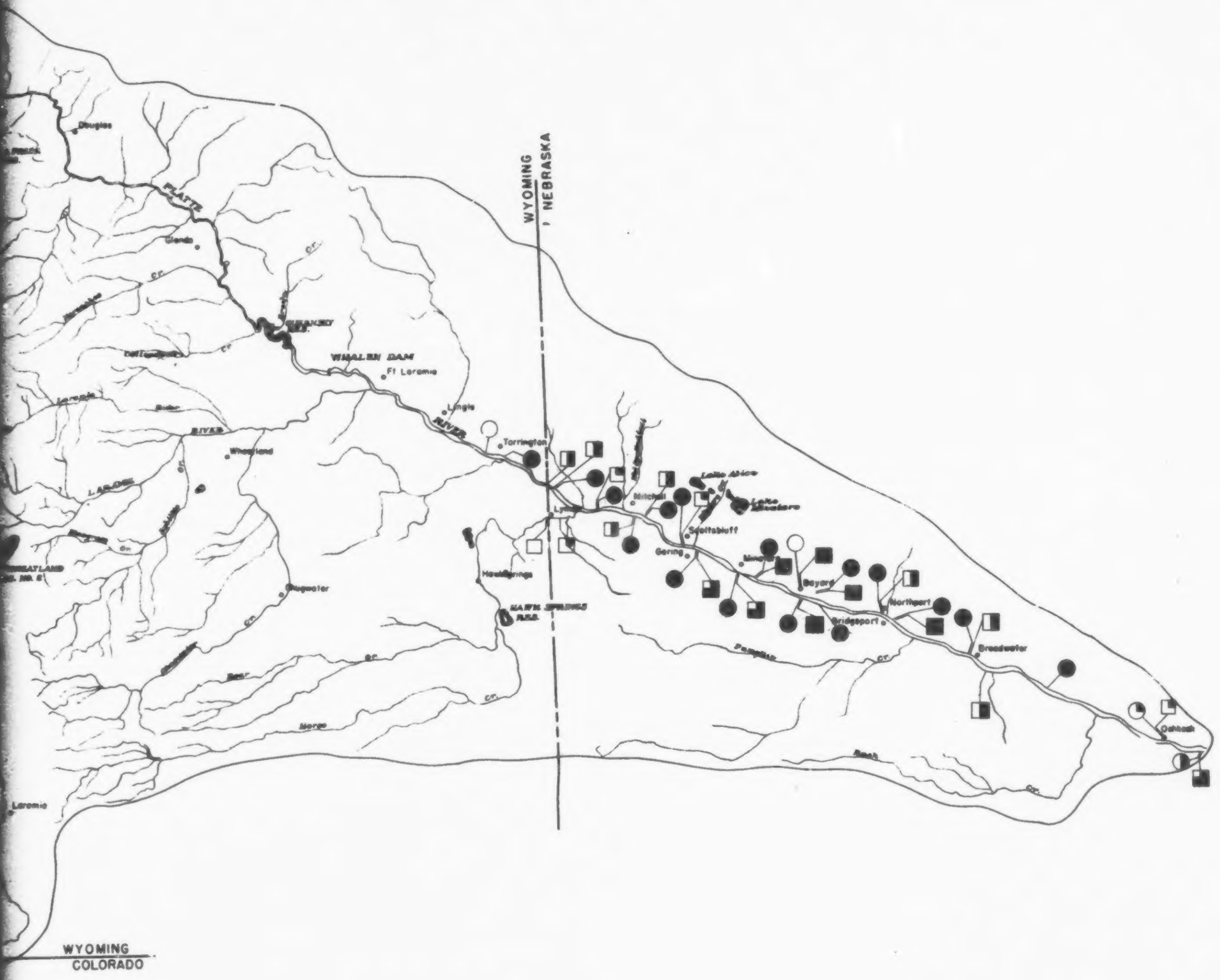
58-B


Atlantic City
So. Pass
Glenrock
NORTH
Casper
Alcova
ALCOVA RES.
PATHFINDER RESERVOIR
KORTES RES.
SEMINOE RESERVOIR
Hanna
Medicine Bow
Rawlins
Sinclair
Ft Steele
Rock River
Wamsutter
BOSLER
Saratoga
Encampment
Walden
LAKE HATTIE RES.
LEGEND
M.P.N. PER 100 ML.
JUNE 1949
OCT.-NOV. 1950
UNDER 2,500
2,501 – 5,000
5,001 – 10,000
10,001 – 20,000
OVER 20,000

A


Douglas
PLATTE
Glendo
Cr.
Cr.
WHALEN DAM
Ft Laramie
Lingle
RIVER
Torrington
WYOMING
NEBRASKA
Laramie
RIVER
Wheatland
LARAMIE
Cr.
WHEATLAND
Chugwater
Cr.
Bear
Cr.
Horse
Cr.
Hawk Springs
HAWK SPRINGS RES.
Lyman
Mitchell
Lake Alice
Lake Minatare
Scottsbluff
Gering
Minatare
Bayard
Bridgeport
Northport
Pumpkin
Cr.
Broadwater
Rush
Cr.
Oshkosh
Laramie
WYOMING
COLORADO

NORTH PLATTE RIVER BASIN

WATER POLLUTION INVESTIGATION

MEDIAN COLIFORM RESULTS

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
DIVISION OF WATER POLLUTION CONTROL

B

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DISCUSSION

Municipal Water Supplies

In the Nebraska part of the North Platte Basin all municipal water supplies are obtained from ground sources. The quality of the water is generally good, and delivery to consumers is without treatment. In the Colorado portion, Walden obtains its water from an infiltration gallery and a well; the former supply is chlorinated.

In the Wyoming section of the Basin water supplies are secured from surface and ground sources. Five surface supplies are taken from the upper North Platte River and tributary creeks in Wyoming: Evansville provides chlorination; Sinclair filters and chlorinates; Encampment, Hanna, and Rock River use untreated creek water. Ground water supplies are obtained from infiltration galleries, springs and wells. Chlorination as a means of disinfection is utilized at Casper, Mills, Saratoga, and Wheatland. Midwest, a community 45 miles outside the Basin to the north, obtains its water by pumping from wells dug along the North Platte River. The water is filtered, chlorinated and softened prior to distribution to consumers.

Public supplies secured from surface waters, those from shallow ground sources, and all supplies showing coliform counts in excess of acceptable drinking water standards, should be chlorinated in addition to other warranted treatment.

The water supply at Casper, Wyoming is worthy of further discussion, since it may be affected by the development program. It is obtained from two sources: the principal source is an infiltration gallery situated along a bank of the North Platte River, and the second supply is obtained from Elkhorn Creek at a point about five miles south of Casper. This latter water which serves 40 homes is passed through a slow sand filter. An objectionable amount of hardness is present in both waters, and commercial water softening firms provide individual units and service to Casper citizens. Average costs vary from $2.50 to $4.00 monthly, and may run as high as $7.00 per month per family.

The water problem has been under study and is considered of primary importance in the development of the municipality. Included in the recommendations of a private citizen's committee is the development of water treatment which would utilize the North Platte River. Treatment would include softening facilities. This plan has been received more favorably than its alternate method, that of extending the present infiltration galleries which would preclude water softening facilities and flexibility of operation. It is recognized that softening would present many advantages. It would reduce soap consumption and wastage, cost of replacing and maintaining plumbing, fuel losses due to boiler scaling (this would also be true in the case of smaller heating installations), and wear and tear of fabrics thus providing increased wearability of garments and other textile articles. It would also provide more incentive for interested industry.

A number of investigators have studied benefits due to water softening. Applebaum[1] writes that $44.00 a year per family of five which had formerly been lost in cost of soaps, plumbing bills, loss of fuel, decreased life of fabrics and increased wear of cooking utensils would be saved. Hoover[2] in his study reported a savings of $48.42 per year per family of five when a water with a hardness of 70 p.p.m. was used in lieu of 270 p.p.m. He presented data to substantiate claims that the family could have afforded to pay five to six times existing water rates and that softening would have cost one-eighth the costs of soap wastage. These figures did not include savings to industry made possible by water softening. Estimates of the cost of softening vary from 75¢ to $2.00 per million grains of hardness removed, in addition to the fixed charges which may reach $2.50 per million gallons when water softening features are incorporated in the design of a rapid sand filter plant.

Figure 12 presents a study from data obtained from the Bureau of Reclamation of the hardness at Casper, Wyoming, from August 1949 to October 1950. During the period of low flow in the North Platte River, values of hardness are high, approaching 600 p.p.m. Reduced hardness occurred when river discharges were increased by releases from the storage reservoirs located upstream. It is interesting to note that even in periods of high flow a hardness in excess of 200 p.p.m. may be experienced. A considerable benefit would accrue to any development project that would reduce the hardness the year around. Figure 12 would indicate that continuous flows of about 1,000 c.f.s. would produce a water having no more than 300 p.p.m. hardness.

Based on average softening costs of $3.25 per month per family an estimated 3,050 families living in the Casper area spend about $120,000 per year to soften that part of the water used for domestic purposes. On the basis of the possible 1,000 c.f.s. dilution water a conservative annual benefit to Casper of $23,000 may be expected. Studies by the Bureau of Reclamation indicate that if a minimum average monthly flow of about 1,050 c.f.s. is maintained at Casper, Wyoming, the resultant softer domestic water supply would accrue an annual benefit of $37,520 to Casper as savings in soap and water softeners. In addition, large quantities of water are softened by the oil refineries in the Casper region. Benefits estimated at $32,000 annually may accrue to industry from increased flows of the North Platte River development program

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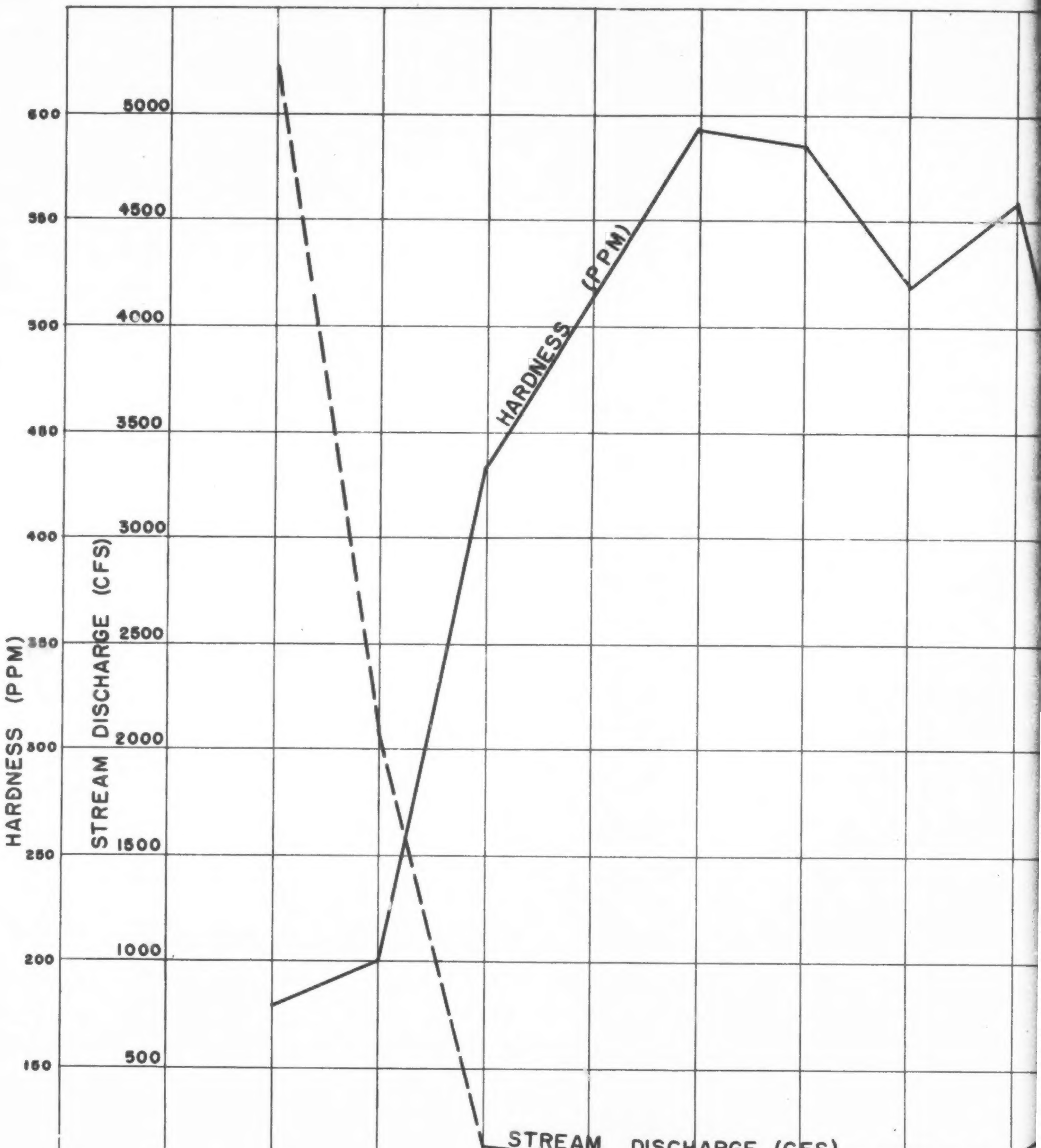
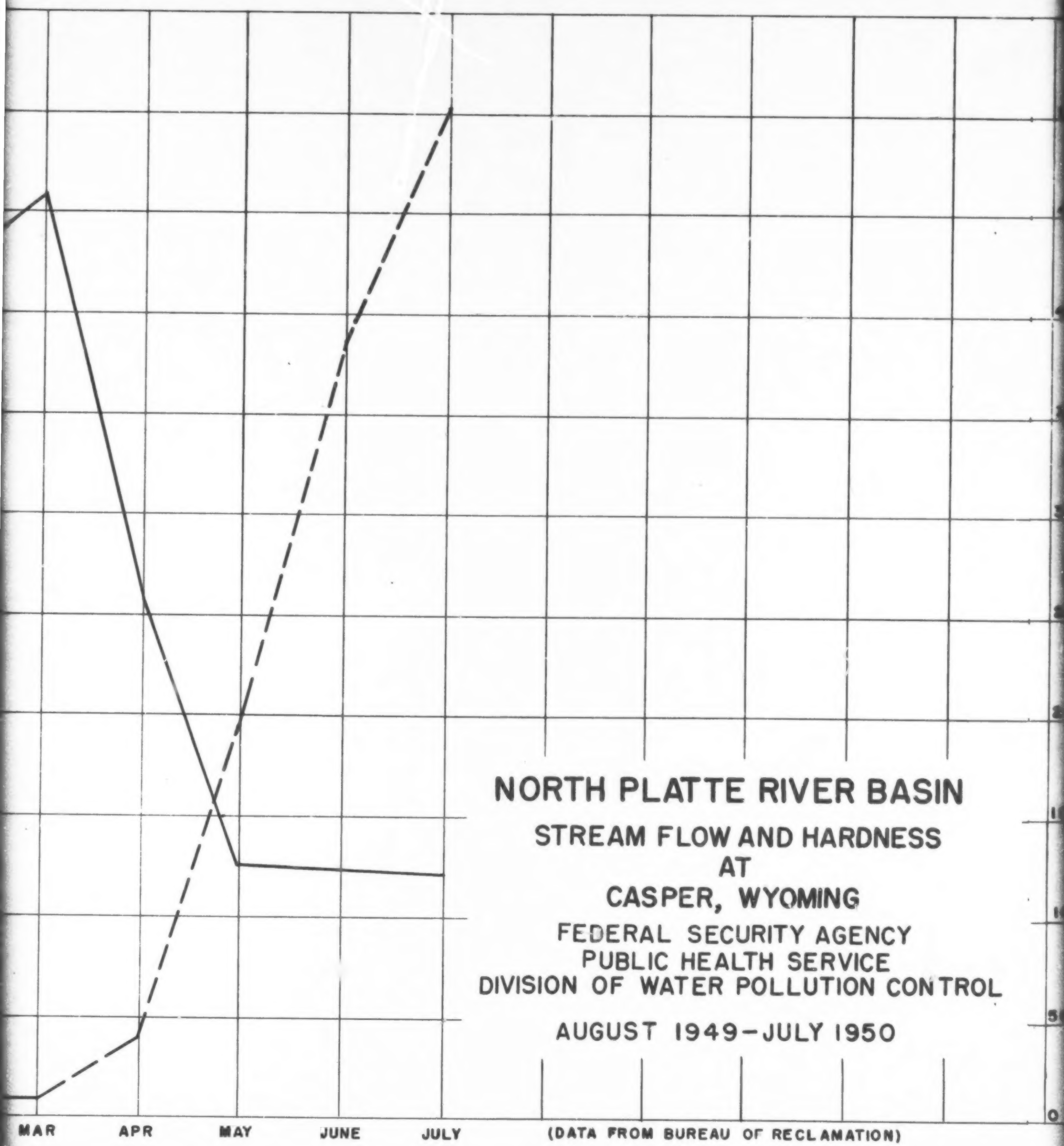
[1] Water Works Engineering, Volume 85, No. 15, July 27, 1932.

[2] National Lime Association, Bulletin 211


HARDNESS (PPM)
STREAM DISCHARGE (CFS)
600
550
500
450
400
350
300
250
200
150
100
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
HARDNESS (PPM)
STREAM DISCHARGE (CFS)
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR

A



NORTH PLATTE RIVER BASIN

STREAM FLOW AND HARDNESS
AT
CASPER, WYOMING

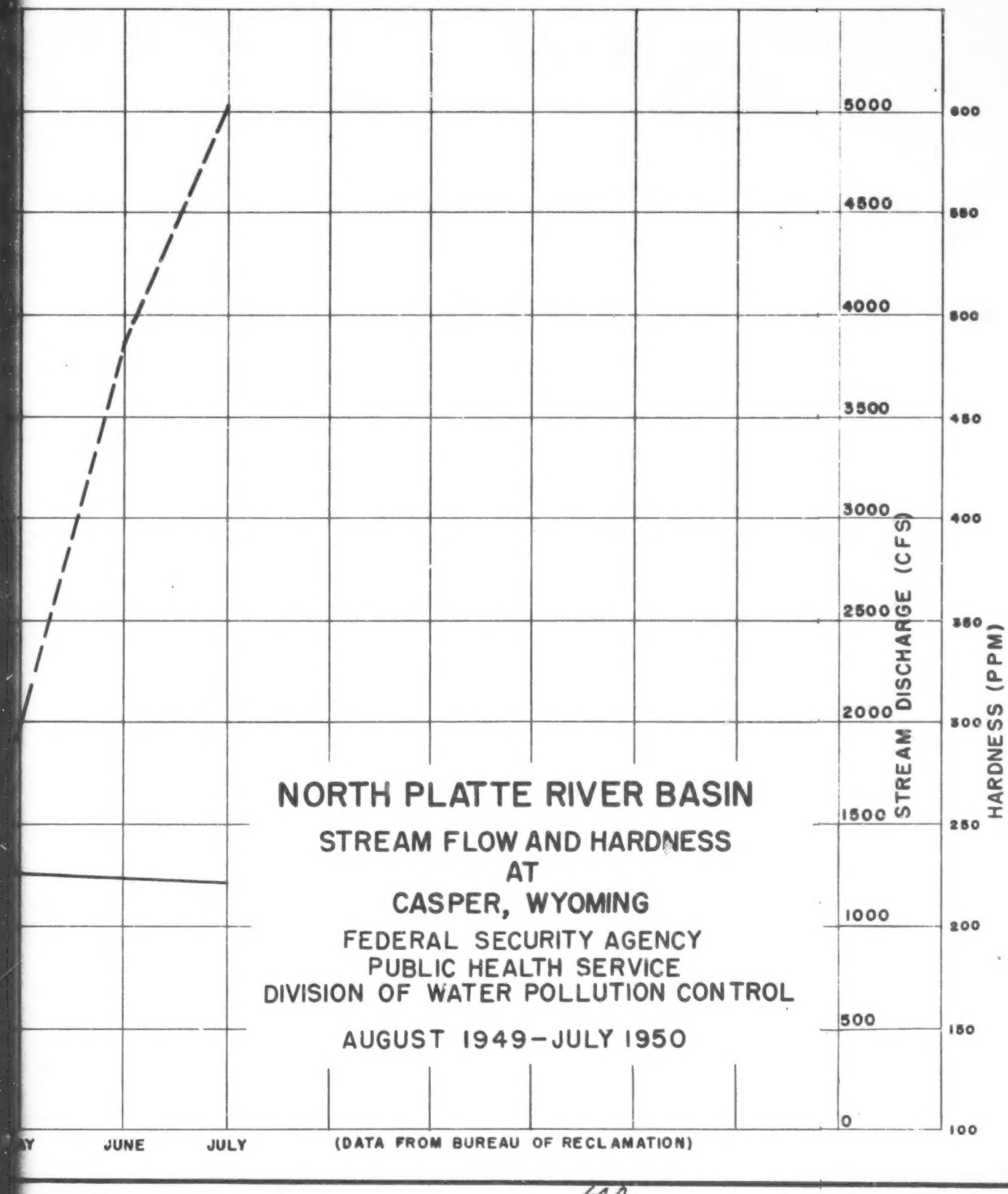
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
DIVISION OF WATER POLLUTION CONTROL

AUGUST 1949–JULY 1950

(DATA FROM BUREAU OF RECLAMATION)

B

FIGURE 12



NORTH PLATTE RIVER BASIN

STREAM FLOW AND HARDNESS
AT
CASPER, WYOMING
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
DIVISION OF WATER POLLUTION CONTROL

AUGUST 1949–JULY 1950

(DATA FROM BUREAU OF RECLAMATION)

that would maintain the hardness of water at 300 p.p.m. or less throughout the year.

The selenium content of soils and waters of sections of the North Platte Basin interposes another public health consideration. Generally accepted drinking water standards state that potable waters shall not contain selenium in excess of 0.05 p.p.m. A sample of water from the North Platte River near Casper, Wyoming, collected during February 1950 and analysed at the University of Wyoming, showed 0.1 p.p.m., or twice the limit for drinking waters. The maintenance of higher flows would probably reduce the selenium value to safe limits and assure a good source of potable water for Casper. Annual examinations of all public water supplies in selenium areas should be made to assay the selenium content. Waters containing more than the accepted amount should be considered hazardous for human consumption.

The difficulty of finding water within the Kendrick project area which contains less than the accepted limit of 0.05 p.p.m. selenium may lead to the use for domestic purposes of waters from Alcova Reservoir and return waters from irrigated land. The use of surface waters will induce added problems having public health significance. The latter water would contain certain additional elements in solution, have increased turbidity, and possibly be contaminated by human and animal wastes which might be washed into channels. Public health hazards would be enhanced by the scattered domestic farm services.

In order to successfully cope with the health hazards associated with the use of irrigation water it would be necessary to plan for such contingencies. The user of such waters should be protected from domestic pollution as well as toxic elements which may be present in the water. It would be necessary therefore that continuous surveillance by health authorities be a part of such a plan. Users of such waters should be advised of the condition of the water and of treatment measures needed to protect themselves.

It has been demonstrated that irrigation practices provide intermittent servicing with water. Domestic use would necessitate that a continuous flow of water be maintained. This might cause operating difficulties to arise, particularly in the maintenance of canals and ditches. The tendency would be to go to pipe distribution systems and raise the cost of water, basing the differential upon a higher domestic water rate. (It is more than possible the increased revenue would justify the improvement).

Inasmuch as the success of the Kendrick development project is contingent upon the provision for an adequate water supply for humans and livestock, an estimated capital benefit of $50 per capita for those securing such supplies would be ascribed to the project if a suitable source of water for domestic consumption is provided. Estimating interest at 4 percent and assuming a life of 20 years for amortization, the annual benefit per capita would be approximately $3.70.

Industrial Water Supplies

The use of water for cooling and processing purposes in the industries of the North Platte Basin constitutes an important demand. It is estimated that oil refineries use approximately 18 million gallons per day, and sugar refineries about 40 million gallons per day. In addition, several small steam electric generating plants use river water for cooling purposes. The quality of water for industrial purposes must be maintained at comparatively high levels. Unduly hard waters produce incrustants which interfere with boiler performance. Polluted waters may be responsible for production of slimes, and are undesirable for processing purposes unless treated. The waters of the lower reaches of the North Platte River are quite highly mineralized, and in places grossly polluted. Several of the major industries have instigated corrective treatment or have sought new sources of supply. Benefits to be derived from additional flows that reduce hardness in industrial water supplies have been discussed in the previous section.

Irrigation Water Quality

Irrigation is practiced in the North Platte Valley below Guernsey Reservoir in Wyoming and throughout the river reach in Nebraska. Industrial wastes, because of location, seasonal discharge, or characteristics, apparently have not affected irrigation usage of river water. However, the use of sewage-polluted water for irrigation introduces a public health problem and its significance should not be neglected. Diversion units located below sources of pollution may disperse pathogenic organisms to irrigated land, and the possible use of such contaminated waters on low-growing crops which may be consumed raw constitutes a health hazard. Chlorination of sewage treatment plant effluent for the elimination of pathogenic organisms may be a requirement. A general discussion of dangers in the use of sewage-polluted waters in irrigation of crops is included as appendix E.

It appears that indiscriminate disposal of human fecal matter also poses a definite public health hazard in irrigated areas. It has been suspected that deposit of human wastes on open fields, or their discharge to irrigation ditches, canals, or drains, brings about wider distribution of ova and cysts of intestinal parasites over irrigated areas, thus increasing chances for their infection of livestock and human beings. It seems likely that itinerant farm labor populations play a considerable role in supplying cysts and ova that may be distributed by water.

Evidence in support of the above suppositions is scanty. Data kindly supplied by the Nebraska State Veterinarian show the incidence of cysticercosis in cattle to be 27 percent for the Scottsbluff area and 7 percent for nonirrigated areas in the State. It is suspected that shipment of cattle from irrigated areas affects the parasite incidence in herds fattened elsewhere. The Nebraska State Department of Health is vitally interested in this problem and has plans to conduct surveys to determine intestinal parasite indices in cross sections of the human populations of both irrigated and nonirrigated areas.

Sources of Pollution and Status of Sewage Treatment

Thirty communities discharge wastes into the streams of the Basin. At Walden, Colorado, wastes are discharged from a primary treatment plant to an irrigation canal. In Wyoming nine municipalities contribute raw wastes to watercourses, four use primary facilities, and three possess secondary treatment plants. Nine municipalities discharge untreated wastes to the North Platte River in Nebraska, two communities use primary treatment facilities, and two have inefficient septic tanks. The magnitude of these wastes as well as the industrial discharges are shown in table 8 and figures 5, 6, 7 and 8.

Numerous other communities now using individual disposal methods may be expected to install sewage systems in the near future. These potential sources of pollution probably will provide adequate sewage treatment, as it is customary for the State water pollution control agencies to require a proper disposal unit as an integral part of the proposed sewage system. Hanna, Evansville, and Chugwater, Wyoming fall into this category.

There are 13 major industrial plants producing wastes in the North Platte River Basin. Seven of these plants are in Nebraska and six in Wyoming. There are six oil refineries, five sugar beet plants, one cannery and one meat packing plant, all located adjacent to the North Platte River. One plant, an oil refinery, provides complete treatment by lagooning. The 12 remaining plants discharge a waste based upon B.O.D. equivalent to a population of 1,950,000. This is greater than the combined populations of Nebraska and Wyoming. If the entire population of the States of Wyoming and Nebraska lived along the North Platte River and discharged their untreated wastes into the stream the effect would not be as great, insofar as biochemical oxygen demand is concerned, as is that from the latter 12 industries. Five sugar beet factories operate for a limited period of 60 to 90 days during the fall season and place the greatest load upon the stream at that time.

Elimination of the industrial wastes is a complex problem to be solved by the industries working with responsible State water pollution control agencies. It appears well within the power of all plants to reduce considerably the strength of their wastes.

Stream Conditions

The North Platte River in the reaches in and around Casper and Torrington, Wyoming, and in the Scottsbluff, Nebraska area, is a grossly polluted stream. Pollution from major industrial sources supplemented by significant domestic sewage is discharged to the stream.

Limnological studies on the North Platte River were made during periods of both high and low water release from storage reservoirs in the summer and autumn of 1950 for comparative purposes. During the period of maximum release from storage the upper part of the stretch studied attains its maximum annual water level; whereas the lower reaches of the river reach their high water level for the year after releases for irrigation have stopped. Due to closure for storage, the times of low flow in the upper region coincide with seasons of greatest annual precipitation.

Great volumes released for irrigation eliminate for the most part any distinctions that could be made between riffles and pools in the upper region, and water rushing down the stream is little affected by the lotic (running water) environment, or by various pollutants discharged into it. Under these conditions water passing from Alcova to Guernsey Reservoir maintains its characteristics as lake water, with very minor modifications, the entire distance. Lake plankters survive for considerable distances downstream, and show response to materials entering in domestic and industrial pollution, although these substances affect the general quality of the water to a very minor degree. Nitrate and phosphate arising from sewage in the Casper region were observed to stimulate lake plankton organisms to greater growth in much the same manner as these substances have been known to increase plankton production in lakes. However, the river benthic forms, particularly insect nymphs and larvae, worms, crustaceans, and snails, have little opportunity to develop during high water periods, since the nearly complete absence of riffles disrupts the normal productive cycle of the stream, and the inherent capacity for biological productivity in the water may be utilized only by the lake plankters and some marginal benthic algae in most regions of the upper stream. During times of high flow trout food production is therefore curtailed; however, the stream does support considerable numbers of rough fishes (suckers and carp) in some sections during high flow, providing food for them in algal growths along the margins.

When releases for irrigation cease, the normal stream divisions, riffles and pools, become established. The usual stream productivity pattern, with riffles as major production areas, returns, and the water above Casper exhibits the usual chemical and physical changes reflecting processes occurring on riffles and in pools. With the arrival of low flow, however, practically the entire stretch of river between Casper and Guernsey Reservoir is seriously affected by discharge of oil refinery waste products in the region from Casper to Glenrock. Materials having the most severe effects upon aquatic life are crude petroleum and phenol. Releases of crude in lethal quantities occur infrequently and probably accidentally. Phenol damage amounts to the most after a batch discharge or when this waste is stored and later released in large quantities. Despite the fact that releases of significant amounts of crude and phenol appear to be at infrequent intervals, they have eradicated fish and fish food organisms for a distance of approximately 110 miles below Casper. During periods between discharges of killing amounts of these toxic substances river life makes some recovery in the form of algal growths and associated protozoans. Intervals between doses of these materials are evidently too short to permit reappearance of larger benthic organisms or fishes, except in a few instances near the mouths of tributaries. Soda lime sludge discharged from water softening processes in the refineries is deposited in banks at varying distances downstream, the lowest bank being east of Glendo, and some 110 river miles below Casper. This deposit has a smothering effect upon bottom organisms and prohibits their occurrence when present in noticeable quantities.

Trout fishing benefits in the North Platte River between Alcova and Guernsey Reservoirs depends upon installation of adequate facilities to prevent releases of toxic refinery products, and upon proper regulation of flow. Riffles or rapids are the major food producing regions in a trout stream, and optimum rate of flow for trout production would need be low enough to insure the regular occurrence of riffle areas, and yet sufficiently high to cover the majority of such areas from bank to bank. It appears likely that a flow of approximately 325 c.f.s. would be adequate to fulfill this need for the stretch concerned. In the interests of the trout fishery alone it would probably be best to regulate the flow in the range of 325 c.f.s. during spring, summer, and early fall, and release greater volumes (1,000 c.f.s. and above) during the winter months.

The lower section of the river, from Guernsey to Lake McConaughy, is markedly affected by withdrawal for and return flow from irrigated lands. Drainage from agricultrual lands results in an accelerated progressive build-up of salts and silt in river water during the growing season, and flow down the river is then at its annual minimum. Effects produced by irrigation greatly restrict the productive capacity of the water, and severe reduction of all forms of aquatic life results. Silting of the bottom and increased turbidity of the water limit all types of benthic organisms in the river, and noticeable development of bottom forms occurs only in those drains that bring clear water to the river. Quantities of lake plankters that come downriver from Guernsey Reservoir are also greatly reduced when the water enters the irrigated areas.

Pollution in the lower region of the North Platte is mainly municipal and that resulting from irrigation, but considerable beet pulp and other wastes from beet sugar refineries enter the stream during fall and early winter. Samples taken during this period indicate that these wastes, due to low water temperatures, have little immediate effect upon the chemistry of the water in ways deleterious to aquatic life, although some oxygen depression may occur. It is possible, however, that deposit of solids from sugar beet processing may have considerable influence upon the river following spring and summer temperature rise. Addition of water laden with by-products of sugar beet processing does noticeably reduce plankton content of river water, even at low temperatures.

As long as present irrigation procedures are maintained in the lower North Platte Basin it will be exceedingly difficult, if not impossible, to make any recommendation that could result in greater production of desirable aquatic life in that section of stream. Maintenance of any sort of fish population there, especially trout, appears to be possible only in the clear water drains. Some trout probably leave these drains for the main stream during nonirrigation seasons, but it is highly improbable that they are able to remain there when the river is affected by irrigation. Development of a sport fishery along with irrigation does not appear likely over most of the region between Guernsey and Kingsley Reservoirs. Duck hunting, on the other hand, appears to be comparatively little affected by irrigation and the beet sugar industry.

The above is a condensed summation of some of the detailed information appearing in the biology section, appendix C.

Sewage and Waste Treatment Needs

Since it is in the States' interest to maintain optimum stream conditions to protect the public health and to prevent nuisance conditions, it is assumed that critical pollution will be abated. Critical conditions can be alleviated by the installation of treatment plants designed to relieve the pollutional load discharged to the stream. The treatment required will depend upon the nature and site of the contributed wastes, upon flow conditions encountered, and downstream water uses. Primary treatment for the removal of settleable solids and floating matter is regarded as a minimum requirement. When normal minimum flows are below the limit required for the dilution of primary treatment effluents, efficient secondary treatment is necessary. Normal minimum flow may be defined as the stream discharge occurring at such a frequency as to form a firm basis for sewage treatment design. It is generally taken as the minimum mean monthly flow to be expected to occur once in five or ten years, depending upon stream conditions encountered at the point in question. Downstream uses, such as public water supply, irrigation and recreation, may necessitate disinfection by chlorination of sewage treatment plant effluents. Sewage treatment needs and status of the proposed projects are listed in table 11. These recommendations are founded upon conditions observed during the pollution investigations, coupled with analyses of available discharge records, and do not reflect a possible increase or decrease in minimum flow resulting from the development program.

Table 11. North Platte River Basin - Sewage treatment requirements and recommendations

Municipality	Remarks	Status
Wyoming		
Rawlins	Plant needed	2
Sinclair	Enlarge existing plant	2
Medicine Bow	Plant needed	2
Casper	Plant needed	2
Standard Oil Refinery	Additional treatment needed	2
Socony-Vacuum Oil Co.	Additional treatment needed	2
Texas Oil Co. Refinery	Additional treatment needed	2
Glenrock	Plant needed	2
Continental Oil Refinery	Additional treatment needed	2
Douglas	Plant needed	2
Guernsey	Plant needed	2
Laramie	New plant needed	1
Wheatland	Plant needed	1
Lingle	Plant needed	2
Torrington	Plant needed	2
Holly Sugar Co. Refinery	Plant needed	2
Nebraska		
Lyman	Plant needed	2
Morrill	Plant needed	2
Mitchell	Plant needed	2
Great Western Sugar Company	Plant needed	2
Scottsbluff	Plant needed	2
Great Western Sugar Company	Plant needed	2
Co-Op. Cannery	Plant needed	2
Co-Op. Oil Refinery	Additional treatment needed	2
Gering	New plant needed	2
Great Western Sugar Company	Plant needed	2
Swift's Meat Packing	Plant needed	2
Minatare	Plant needed	2
Melbeta	New plant needed	2
Bayard	Plant needed	2
Great Western Sugar Company	Plant needed	2
Bridgeport	Plant needed	2
Broadwater	Plant needed	2
Oshkosh	Plant needed	2

Status: 1. Plans or report under way
2. Project needed. No program known

The following communities should install a minimum of effective primary treatment: Rawlins, Medicine Bow, Guernsey, Wheatland, Lingle, and Torrington, Wyoming; Lyman, Morrill, Minatare, Melbeta, Bayard, Bridgeport, Broadwater, and Oshkosh, Nebraska. Sinclair should enlarge its present primary treatment plant. Hanna, Chugwater and Evansville, Wyoming, when sewerage is installed, should provide a minimum of primary treatment.

Satisfactory secondary treatment should be provided by: Caspor, Glenrock, Douglas, and Laramie, Wyoming; Scottsbluff, Mitchell and Gering, Nebraska. Laramie will require a very high degree of treatment.

Industry operating the year around should remove completely all toxic wastes and provide treatment for the organic constituents equivalent to that of the adjoining municipalities. Flows normally occurring in the North Platte River indicate that secondary treatment will be needed by industry. The quantity of seasonal wastes contributed by beet sugar refineries indicates an urgent need for the maximum possible reduction in wastes produced and effective treatment of the remainder prior to discharge. This must be equivalent to a very high degree of secondary treatment. The sugar refinery at Wheatland, Wyoming, was not operating, but, should it reopen in the future, provisions for waste reduction and treatment will be necessary to prevent pollution in Rock Creek and Laramie River.

Flow Needs: Benefits and Damages

The development program may provide increased minimum flows sufficient to permit a lower degree of sewage treatment, to enhance fish and wildlife values, and to improve water quality for municipal and industrial uses. These results would provide tangible monetary benefits attributable to the development program. Contrariwise, damages may result if flows are reduced below the required minimum by water diversion to other uses. In this connection it may not be assumed that damage will not result if regulation provides the minimum flow at a value equal to the unregulated minimum previously prevailing. Stream conditions would be equal to those existing during unregulated minimums, and would be worse during the time regulated discharges are less than those that would naturally occur.

Desirable flows specified are those required to assimilate the residual organic matter from the designated treatment process without lowering the dissolved oxygen level below that required for balanced aquatic life. Useful desirable flows (tables 12 and 13) are based upon a minimum of efficient primary treatment (35 percent B.O.D. removal) and a minimum of 5.0 p.p.m. dissolved oxygen in the stream. Secondary treatment desirable flows assume efficient secondary treatment (a minimum of 75 percent B.O.D. removal) and a minimum of 5.0 p.p.m. dissolved oxygen in the stream. Winter conditions and ice cover have been considered.

Table 12. North Platte River Basin - Flow needs and cost evaluation based on waste treatment

1	2	3		4		5		6		7	8		9
Municipality and State	Approximate miles from mouth	Minimum normal flow[e] c.f.s.		Useful desirable minimum flow[a] c.f.s.		Secondary treatment desirable minimum flow		Necessary to prevent damage		Annual tangible monetary benefits if flow in column 4 is provided	Preliminary Est: Minimum mean monthly flow in c.f.s. under proposed flow regulation program		Annual tangible benefits (+) and damages (-) under proposed regulation program - Estimated flow in column 8
		S[1]	W[2]	S	W	S	W	S	W		S	W	
North Platte River													
Casper, Wyo.	396	450	55	325	200[c]	125	75[c]	125	55	$ 55,400	100[f]	920	0[f]
Glenrock, Wyo.	366	460[b]	75[b]	325	200[c]	125	75[c]	125	75	3,250	160[b] [f]	980[b]	0[f]
Torrington, Wyo.	209	400[b]	100[b]	15	700[d]	6	270[d]	15	100	92,000	-	-	-
Mitchell, Nebr.	184	90	430	15	410[d]	6	160[d]	15	410	0	70	150	-25,000
Scottsbluff, Nebr.	174	90[b]	510[b]	175	1,850[d]	70	710[d]	90	510	117,700	72	250	-48,000
Gering, Nebr.	174	90[b]	510[b]	175	1,850[d]	70	710[d]	90	510	85,000	72	260	-22,000
Bayard, Nebr.	150	120[b]	590[b]	20	410[d]	10	160[d]	20	410	0	120	760	0

[1] Summer - June, July, August, September.

[2] Winter - December, January, February.

[a] Based on primary treatment.

[b] Estimated.

[c] Based on partial ice cover - if ice cover does not interfere with reaeration, flows may be reduced 50 percent.

[d] October flows (maximum) for beet sugar wastes - see table 15 for monthly variations.

[e] Mean monthly flows that occur at such a frequency as to form a firm basis for sewage treatment design (see text).

[f] Tentative flow revisions by Bureau of Reclamation indicate a minimum of 500 c.f.s. - benefits resulting from flow regulation would be that shown in column 7 for Casper and Glenrock.

Table 13. North Platte River Basin - Flow needs by months for critical locations

Month	Casper, Wyo.		Torrington, Wyo.		Mitchell Nebr.		Scottsbluff-Gering, Nebr.		Bayard, Nebr.	
	1	2	1	2	1	2			1	2
January	200[a]	75[a]	440	170	255	100	1160	450	255	100
February[b]	200[a]	75[a]	350	130	200	80	900	350	200	80
March[b]	200[a]	75[a]	350	130	200	80	900	350	200	80
April[b]	150	50	200	80	130	50	580	220	130	50
May	200	75	15	6	15	6	175	70	20	10
June	325	125	15	6	15	6	175	70	20	10
July	325	125	15	6	15	6	175	70	20	10
August	325	125	15	6	15	6	175	70	20	10
September	325	125	15	6	15	6	175	70	20	10
October	150	50	700	270	410	160	1850	710	410	160
November	200[a]	75[a]	550	215	315	120	1420	550	315	120
December	200[a]	75[a]	440	170	255	100	1160	450	255	100

[1] Desirable flows - primary treatment.

[2] Secondary treatment flows.

[a] Based on partial ice cover.

[b] Beet sugar refineries do not operate these months but wastes from the plants may continue - designated flows consider these wastes.

Refinement beyond primary treatment represents a substantial financial investment. Possible benefits may accrue where flow can be increased to permit satisfactory stream conditions with primary treatment only, thereby effecting sizable savings in initial plant costs as well as operation, maintenance, and replacement. This saving is considered a direct benefit from the increase in stream discharge and the benefit may reach considerable proportions when the river receives the discharge of many communities. Benefits have been assigned a monetary value based upon the differential of estimated annual costs of primary and secondary treatment amortized for 20 years at 4 percent interest, plus maintenance and operation.

Primary treatment is inadequate for those cases having a normal expected minimum flow less than the desirable, and a higher degree of treatment is required. In these instances primary treatment would be adequate contingent upon a regulation program which would provide a minimum flow equal to or greater than the desirable flow. Benefits would result in savings due to the possible lower degree of treatment. No benefits for treatment are possible when the normally expected discharges are equal to or greater than the desirable flow corresponding to primary treatment.

Damages may occur when flow regulation reduces stream discharges below: (1) the normal minimum historic flows, or (2) below that required for ultimate disposal of primary treated sewage, whichever is the lower flow. Damages represent additional sewage treatment requirements needed to maintain stream conditions equivalent to that existing before flow regulation.

Flows designated as desirable in tables 12 and 13 are based upon the specified degree of treatment. Sewage and waste treatment benefits and damages in table 12 have been founded on normally expected minimum flows, flows recommended as useful desirable minimums, and estimated flows under proposed regulation.

If it is possible for the development program to meet the useful desirable minimum flows in all instances, a monetary benefit of over $300,000 in reduced sewage treatment would accrue to the project. Of this sum $58,650 represents the Casper-Glenrock reach where the useful flows appear within possibility of achievement with development of potential Glendo Reservoir. Present estimated flows of the proposed regulation program will not provide cost benefits but will possibly cause damages in the Scottsbluff region approaching $95,000.

In this study other benefits have been considered such as the development of a game fishery and improvement in water quality for municipal and industrial use. Considering the Casper-Glenrock reach only, flow regulation introduces several possibilities. First, an annual tangible benefit amounting to $58,650 is possible contingent upon the provisions of an adequate flow for the dilution of primary treated sewage and equivalent treatment of industrial wastes. Second, although the summer useful flow for the above benefit would provide excellent conditions for the propagation of fish life in the stream, it is believed that it will be necessary to provide a safety factor to insure against fish life destruction due to inadvertent, accidental or uncontrollable industrial pollution. Thus, a flow of 600 c.f.s. on a year around basis will insure added annual fish life benefits estimated by the Fish and Wildlife Service as $50,000. Third, additional benefits are possible if a low minimum flow of 1,000 second-feet is provided. This flow would reduce the hardness of the water sufficiently to result in a savings of an estimated $23,000 annually to the citizens of Casper and a benefit of about $32,000 annually to the industry in the Casper area. If 600 second-feet can be provided, about $38,000, or 70 percent, of benefits in water hardness reduction attributed to 1,000 second-feet flows can be realized. Thus, for this region annual benefits from 1,000 c.f.s. flow regulation will be as follows: savings in sewage treatment $58,650; savings in water softening $55.000; fishery value $50.000; total $163,650. Similarly, a sustained flow of 600 c.f.s. would result in savings estimated at $146,650.

In the Scottsbluff region benefits may be more difficult to develop because of prior water use. However possible benefits would approach $294,700 if sufficient flows could be provided to permit only primary treatment of sewage and industrial wastes. Damages based upon estimated flow under the proposed regulation program would approach $95,000, but would not become effective until all wastes discharged in this region receive effective secondary treatment.

Table 14 includes a summation of benefits and damages as discussed above. It has not been deemed practical in a Basin-wide report of this type to provide an analysis of various possible conditions and requirements at each point. Special investigational work will be needed to supply such detailed information.

Dam and Reservoir Effect on Pollution Assimilation

Impoundments serve to reduce organic pollution which enters the storage basin. Decreased velocities permit sedimentation, and additional detention time enables biological action to reduce organic wastes; clarification permits development of algal growths. However, sedimentation of organic wastes could cause localized nuisances due to development of sludge banks which would use the dissolved oxygen available in waters of the reservoirs. Reaeration of a high degree is effected when flow passes over spillways and tailraces. The oxygen acquired in this manner adds to the assimilative capacity of a stream. A low-head dam below Casper, Wyoming would assist appreciably in improving the downstream fishery provided all toxic industrial wastes are prevented from discharging to the stream and organic wastes receive adequate treatment compatible with flows provided.

Table 14. North Platte River Basin. Summary Table - Annual benefits and damages

Region	Minimum flow requirements	Benefits	Damages
Casper (Casper to Glenrock reach)	Useful minimum (table 13)	$ 58,650	
	600 c.f.s.	146,650	
	1000 c.f.s	163,650	
	Proposed routing	0[a]	0
Scottsbluff (Torrington to Lewellen reach)	Useful minimum (table 13)	294,700	
	Proposed routing	0	$ 95,000

a. Tentative revision of flow routing by Bureau of Reclamation indicates a minimum of 500 c.f.s. with an attributable annual benefit of about $146,650.

Affect of Reservoir Backwater

The construction of reservoirs requires consideration of the backwater engendered through the development of the impoundment and its possible effects upon a program of sewage disposal. Backwater may inundate sewage plants and appurtenances, or reduce the flow of the stream, thereby enhancing sedimentation with the possibility of creating local nuisances.

In the event of the construction of potential Fort Steel Dam for hydroelectric power purposes, the backwater would cause inundation of the existing Sinclair waterworks located on the North Platte River about one-half mile above its confluence with Sugar Creek. The damage to the water plant and the construction cost of a new intake and collection appurtenances is estimated at $300,000.

APPENDIXES

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APPENDIX A

MEMORANDUM OF UNDERSTANDING RESPECTING JOINT PROGRAM FOR STREAM POLLUTION INVESTIGATIONS OF THE NORTH PLATTE RIVER BASIN

This MEMORANDUM OF UNDERSTANDING, Made and entered into this 14th day of December, 1949, pursuant to the authority contained in the Acts of June 17, 1902 (32 Stat. 388), and acts amendatory thereof or supplementary thereto, known as the Reclamation Laws, and the Act of December 22, 1944 (58 Stat. 887), by and between the BUREAU OF RECLAMATION and the PUBLIC HEALTH SERVICE, as party of the second part, is as follows:

1. Beginning on or about December 27, 1949, or as soon thereafter as feasible:

(a) The Public Health Service will conduct a stream pollution survey of the North Platte River and its tributaries above Lake McConaughy to include, among others,

(1) A determination of the extent, types and major sources of pollution.

(2) A review of existing laws and pending legislation regarding pollution of public waters in the States of Wyoming, Nebraska and Colorado.

(3) An evaluation of the sanitary quality of irrigation water at present and proposed impoundments, diversion points, and in existing canals.

(4) A recommendation regarding minimum stream flows below the reservoirs for public water supplies and for sanitation purposes with present and contemplated pollution.

(5) An evaluation of the sanitary quality of water for municipal requirements and other public uses.

(6) An estimate of possible benefits to abatement of water pollution problems by reservoir releases.

(7) Recommendations and existing plans for pollution abatement.

The Public Health Service shall assume full responsibility for the survey and the preparation of complete reports thereon. An interim report will be submitted on or before May 1, 1950, which may be in the form of a memorandum, to supply an interpretation of such data as is available at that time for use in the preparation of the draft of the Bureau of Reclamation Comprehensive Basin Report. A final report which will include the findings, conclusions, and recommendations will be submitted as soon as practicable after the completion of field work but not later than November 1, 1950. Fifty copies of the final report will be submitted to the Bureau of Reclamation. In addition, the Public Health Service will consult with officials of the States of Wyoming, Nebraska and Colorado relative to pollution problems as involved in the North Platte River Basin, and copies of the reports made by the Public Health Service will be furnished to these State officials.

(b) In connection with the survey contemplated herein, the Public Health Service, cooperatively with the Wyoming, Nebraska and Colorado State Health Departments, will furnish, as required, the following services and facilities:

(1) Professional and sub-professional personnel as necessary for this study.

(2) Automotive and all other necessary equipment.

(c) The Bureau of Reclamation will pay not to exceed $8,300 of the actual costs incurred by the Public Health Service between the date of this memorandum and July 1, 1950, in making the stream pollution survey, provided, however, such costs shall not include the purchase of non-expendable equipment. Transfer of funds will be made monthly to the Public Health Service by the Bureau of Reclamation on Form 1080 upon receipt by the Bureau of statements showing the expenditures hereunder by the Public Health Service.

In addition, the Bureau of Reclamation will supply for the use of the Public Health Service in connection with the stream pollution survey such of the following as may be required by the Public Health Service:

(1) Limited drafting assistance as can be made available with the regular staff of the field office and as time permits.

(2) Maps, charts, hydrologic and other available data.

2. Where the operations of this contract extend beyond the fiscal year 1950, the contract is contingent upon appropriations to the Public Health Service for expenditures hereunder beginning July 1, 1950.

3. No Member of or Delegate to Congress or Resident Commissioner shall be admitted to any share or part of this contract or to any

benefit that may arise herefrom, but this restriction shall not be construed to extend to this contract if made with a corporation or company for its general benefit.

IN WITNESS WHEREOF, The parties hereto have caused this memorandum of agreement to be executed as of the day and date first above written.

BUREAU OF RECLAMATION	PUBLIC HEALTH SERVICE
By (Signed) J. A. Keimig	By (Signed) Glen J. Hopkins
J. A. Keimig	Glen J. Hopkins
Acting Director	Officer in Charge
Region 7	Missouri River Basin Office
Denver, Colorado	Kansas City, Missouri

AMENDMENT TO MEMORANDUM OF UNDERSTANDING RESPECTING JOINT PROGRAM FOR STREAM POLLUTION INVESTIGATIONS OF THE NORTH PLATTE RIVER BASIN

In order that the Public Health Service may complete the survey of the North Platte River and its tributaries above Lake McConaughy as prescribed in the "Memorandum of Understanding Respecting Joint Program for Stream Pollution Investigations of the North Platte River Basin" made and entered into between the Bureau of Reclamation and the Public Health Service on December 14, 1949, said Memorandum of Understanding is hereby amended as follows:

1. The date of "July 1, 1950" as it appears in Section 1(c) shall be changed to read "December 15, 1950".

2. Section 2 shall be deleted in its entirety.

IN WITNESS WHEREOF, The parties to the afore-mentioned Memorandum of Understanding have caused this amendment to be executed this 19th day of May, 1950.

BUREAU OF RECLAMATION	PUBLIC HEALTH SERVICE
By (SIGNED) Avery A. Batson	By (SIGNED) Glen J. Hopkins Glen J. Hopkins Officer in Charge
Region 7 Denver, Colorado	Missouri River Basin Office Kansas City, Missouri

APPENDIX B

SUGGESTED STATE WATER POLLUTION CONTROL ACT*

EXPLANATORY STATEMENT

Increasing interest in development and conservation of our country's water resources has been reflected in the concern which legislatures have shown with the problem of water pollution. Within the last decade more than half the States have adopted new legislation in this field or strengthened existing laws, and in 1948 the Congress passed the Water Pollution Control Act, the first attempt by the Federal Government to join with the States in a comprehensive attack on the problem as a whole. A "Suggested State Water Pollution Control Act" has been prepared as a part of this effort.

The underlying concept and purpose of this legislation is to facilitate interstate cooperation for a more concerted attack on water pollution. Many benefits would be derived if the States adopted legislation uniform in basic principles. It is not expected that the States will repeal their existing legislation and adopt this suggested law. The process of obtaining uniformity is one of evolution. It is suggested that the States take a realistic look at their basic statutes in the field of water pollution control and compare them with the suggested law. Those familiar with State law in this field will find little that is new in the suggested draft. Basically, what has been done has been to adopt the best practices from existing State statutes and using these as a framework to develop a statute that could aid and strengthen the State programs.

A preliminary draft of the "Suggested Act" was submitted for comment to a large number of State sanitary engineers; lawyers; conservationists; industrialists; sportsmen's, wildlife and conservation, agricultural and recreational groups; national lay organizations; municipal organizations; and other persons interested in this field. Subsequently, the preliminary draft, together with comment which was received from all parts of the country, was considered and discussed by a board of expert consultants meeting in Washington. The "Suggested Act" was prepared and revised in light of comments and suggestions resulting from the foregoing procedures.

State water pollution control legislation developed traditionally out of the authority of health departments to preserve public health. In conjunction with this there was piecemeal lodging of concurrent water pollution control authority in several other departments of State governments such as those dealing with agriculture, fish and wildlife, and mines and minerals which also had an interest in water pollution control. The modern approach to the problem is reflected in recent State statutes whose object is to preserve and improve water quality for all legitimate uses and do this through an agency that represents all affected interests in the State. Accompanying this has been a shifting emphasis from the mere abatement of existing pollution to the policy of preventing pollution in its incipiency.

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* Prepared by Division of Water Pollution Control, Public Health Service, Federal Security Agency, Oct. 1950.

In the early statutes the administrative approach was largely negative in character. That is, when a particular action was found to cause pollution the administrative agency was authorized to take steps to abate such pollution. The Suggested State Water Pollution Control Act follows the more recent statutes by authorizing the agency to develop a comprehensive program to deal with the problem in all waters of the State. Under this approach, the agency, having determined permissive limits of waste discharges into the waters of the State, uses its enforcement procedure to abate existing pollution and restore the quality of polluted waters, while through a system of permits it prevents any increase in waste discharges which would impair desired water uses.

The Act is designed to give the agency broad discretion in administration of the program and makes its jurisdiction complete over all waters of the State. It avoids such restrictive practices as exemption of particular industries or geographic areas and legislative classification of particular streams for specified water uses.

While the Act is complete in itself, it rests on a framework of other State statutory and constitutional provisions. Perhaps one of the most important of these relates to municipal financing. No water pollution control program can operate successfully unless the State and its political subdivisions can finance the construction and operation of remedial works for treatment of wastes. The Suggested State Water Pollution Control Act does not treat this subject in view of its complexity and the numerous individual problems peculiar to particular States. Reference is made to the Council of State Government's 1949 program of suggested State legislation for a general approach to the problem and suggestions for individual States.

While a section-by-section analysis of the Act will not be attempted, some comments may be directed to its principal features.

Pollution. The most important definition in the Act is the definition of "pollution," which is designed to protect all legitimate uses of waters of the State. To this end, "pollution" as defined includes both discharges of wastes actually or potentially harmful to such uses and also altering the properties of the waters in such a way as to be harmful. The latter, for example, would cover heating of water in such a way as to deplete oxygen supply and reduce the capacity of the water to support fish life or stabilize discharges of wastes. This definition must be read together with subsequent sections of the Act authorizing the classification of waters and the setting of standards of water quality. Discharges which violate such standards and classifications are declared unlawful, but discharges consistent with them are not considered "pollution" for purposes of the Act. The Act, therefore, gives effect to the agency's action in classifying waters and setting standards but does not hold its enforcement powers in abeyance until such action can be completed.

Type of Administrative Agency. One of the most important questions for any State to decide in preparing water pollution control legislation is the agency to which enforcement of the program will be entrusted. As has been said, most early legislation of this type vested authority in the State health department. The problems of water pollution control, however, concern other interests than health, and in a broader sense are an integral part of the problem of preserving the water resources of the State. For example, wildlife and conservation interests, industry, municipalities and agriculture have a stake in the enforcement of a water pollution control program. It is believed important that any agency which is set up to administer such a program should be so constituted as to take into account the interests and views of these and other affected groups in addition to health considerations.

Most States which have recently enacted water pollution control legislation have entrusted its enforcement to a board representative of the interests considered to be affected. Such boards are sometimes made up of representatives of various departments of the State government, sometimes of citizens from outside the government, and more frequently of a combination of the two. Adoption of this form has the advantage of facilitating representation of affected interests in the agency. If it is adopted, provision should also be made for an executive secretary to serve as the administrator of the program and to carry out the policies adopted by the board. Some States may wish to vest responsibility for the program in a single administrator. If this is done, it would seem advisable to secure representation of affected interests through an advisory council, and it may also be considered desirable to set up a board of review to hear appeals from the single administrator's decisions.

The Suggested State Water Pollution Control Act has incorporated alternative provisions covering both the board and the single administrator type of agency.

States adopting water pollution control legislation recently have in some cases set up completely independent agencies, but have more frequently placed the agency within an existing State department, generally the department of health. This is a matter for determination by each individual State. Where the agency is set up within an existing State department, however, it is believed desirable to vest it with authority to act independently since an agency representing so broad a field of the State interests should not be subjected to the supervisory control of any single State department which operates in a comparatively narrower field.

Where the agency is established in an existing State department it is recommended that it be placed in the State health department. Not only is health a major public interest and an integral part of an active water pollution control program, but also the health department usually has trained personnel and facilities which may be utilized for work in connection with the water pollution control program. It will usually be true that the health department is already carrying on some of the functions which this Act vests in the new agency. Use of health department personnel and facilities therefore will avoid unnecessary duplication of functions.

Classification of Waters--Standards of Water Quality. Some agencies in the administration of water pollution control programs have classified the waters of the State according to their use and have established standards of quality for such waters in accordance with their respective uses. Proponents of this method have urged that classification and setting of standards is an essential element of any comprehensive program and also that no enforcement action can be undertaken without determination of the use to which a particular body of water should be put and the degree of quality which the water must have in order to be suitable for such use. This approach, however, has been severely criticized by others who maintain that the process is administratively difficult and time consuming, that classifications once made are hard to change and tend to create vested interests, and that the tendency will be to reduce waters to the level of mere carriers of wastes because of the pressure of special interests.

The Suggested State Water Pollution Control Act authorizes the agency to classify waters and set up standards of quality for water falling within particular classifications but does not make it mandatory to do so. Classifications and standards once promulgated have a definite legal effect and their violation is made unlawful; conversely, discharges which comply with such classifications and standards are not pollution within the meaning of this Act. In view of the number of persons affected by classifications and standards, it is required that their adoption be preceded by a public hearing open to all residents of the areas affected, and that adequate notice thereof be given. The Act provides that in classifying waters and setting standards the agency will be guided by the principle of constantly seeking to improve water quality and upgrading streams for progressively higher uses to the maximum extent practicable.

Permits. Potentially one of the most effective techniques for control of water pollution is a permit system, under which discharges of wastes into any waters of the State are prohibited except as permitted by the agency after examination of plans, specifications and other data. Through this means the agency can either prohibit discharges altogether or condition their approval on treatment adequate to protect legitimate water uses. The Act contains broad provisions authorizing the agency to require permits for waste discharges and additions to plants which would result in increased pollution. Normally, the permit system would be restricted to new pollution or increases in existing waste discharges, but the breadth of the language employed is sufficient to enable the agency to extend the requirement to existing discharges where this is considered desirable administratively.

Enforcement. The Act affords a variety of methods for proceeding against any alleged polluter. It is made unlawful to cause any pollution of the waters of the State or to violate any order issued by the agency, including an order establishing a classification of waters or standards of water quality. Pollution of waters of the State is declared to be a public nuisance and is therefore subject to abatement in accordance with State practice for abatement of nuisances. Violation of the provisions of the Act or any order or determination by the agency or failure to perform any duty imposed by the Act is declared to be a misdemeanor. In addition, the Attorney General has the duty to bring an action for an injunction against any person violating any provision of the Act or any order of the agency. The principal method of making the program effective through compulsory process, however, is by administrative action. The agency is empowered to issue orders against alleged polluters after adequate opportunity for hearing. Such orders if not appealed to the courts become final and are enforceable in much the same way as the judgment of a court. The same administrative hearing procedure is employed in cases of revocation, denial or modification of permits.

Appeals may be taken to the courts from orders of the agency. Such appeals do not involve trial de novo but are primarily reviews of the legal propriety of the agency's decision. If the prescribed statutory procedure has been followed and the determination is supported by substantial evidence, the order of the agency will be affirmed by the court.

It is recognized that the provisions of the Act for administrative hearings and judicial review will not be appropriate in all cases. Each State will necessarily adapt them to their own administrative and judicial practice and existing statutes. The provisions of the Act, however, embody principles which are believed desirable in this type of legislation.

Administrative Powers. The Act confers on the agency the requisite administrative powers to carry out its responsibilities. Thus the agency is empowered to hold hearings, subpoena witnesses, enforce its subpoenas, administer oaths, examine plans and specifications, require the keeping of records and the making of reports, and enter on property at reasonable times for purposes of inspection and investigation.

The Council of State Governments endorses the "Suggested State Water Pollution Control Act" and recommends it to States for favorable consideration.

10/4/50

SUGGESTED STATE WATER POLLUTION CONTROL ACT

(Title. It should conform to State requirements. The following is a suggestion; a more complete title should be used where necessary.)

"AN ACT to establish a State water pollution control agency, and to control, prevent and abate pollution of the surface and underground waters of the State."

(Be it enacted, etc.)

Section 1. Statement of policy.[1] Whereas the pollution of the waters of this State constitutes a menace to public health and welfare, creates public nuisances, is harmful to wildlife, fish and aquatic life, and impairs domestic, agricultural, industrial,[2] recreational and other legitimate beneficial uses of water, and whereas the problem of water pollution in this State is closely related to the problem of water pollution in adjoining States, it is hereby declared to be the public policy of this State to conserve the waters of the State and to protect, maintain and improve the quality thereof for public water supplies, for the propagation of wildlife, fish and aquatic life, and for domestic, agricultural, industrial, recreational and other legitimate beneficial uses; to provide that no waste be discharged into any waters of the State without first being given the degree of treatment necessary to protect the legitimate beneficial uses of such waters; to provide for the prevention, abatement and control of new or existing water pollution; and to cooperate with other agencies of the State, agencies of other States and the Federal Government in carrying out these objectives.

Section 2. Definitions. For the purposes of this Act, the following words and phrases shall have the meanings ascribed to them in this section.

(a) "Pollution" means such contamination, or other alteration of the physical, chemical or biological properties, of any waters of the State, or such discharge of any liquid, gaseous or solid substance into any waters of the State as will or is likely to create a nuisance or render such waters harmful or detrimental or injurious to public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to lifestock, wild animals, birds, fish or other aquatic life.

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[1] Where a State has committed itself to a general water resources program, a declaration to the effect that water pollution control is an integral part of such program should be added.

States in the West and Southwest may want to add a statement to the effect that water pollution control is basically a water conservation program in their States.

[2] Specific wastes which are of particular interest to an individual State may be included, such as mine wastes, etc.

(b) "Wastes" means sewage, industrial waste and all other liquid, gaseous or solid substarces which may pollute or tend to pollute any waters of the State.

(c) "Sewerage system" means pipe lines or conduits, pumping stations, and force mains, and all other constructions, devices, appurtenances and facilities used for collecting or conducting wastes to a point of ultimate disposal.

(d) "Treatment works" means any plant, disposal field, lagoon, dam, pumping station, incinerator, or other works used for the purpose of treating, stabilizing or holding wastes.

(e) "Disposal system" means a system for disposing of wastes, and includes severage systems and treatment works.

(f) "Waters of the State" means all streams,[3/] lakes, ponds, marshes, watercourses, waterways, wells, springs, irrigation systems, drainage systems, and all other bodies or accumulations of water, surface and underground, natural or artificial, public or private, which are contained within, flow through, or border upon this State or any portion thereof.

(g) "Person" means the State, any municipality, political subdivision, institution, public or private corporation, individual partnership, or other entity.

[3/] Seaboard States should include within this definition such coastal waters as are within the jurisdiction of the State.

Section 3. Creation and Organization of Board; Meetings; Employees. There is hereby created and established[4] a State water pollution control board hereinafter referred to as the "Board" which shall be composed of ___ members as follows: The Director of the Department of Health; the Director of the Department of Agriculture; the Director of the Department of Conservation, Fish and Game; and two members appointed for terms of____ years by the Governor. One of the members appointed by the Governor shall be experienced in the field of municipal government and one shall be experienced in the field of industrial activities.[5] The Board is directed to carry out the functions and duties conferred on it by this Act.

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[4] The State water pollution control authority may be set up as an independent board or may be established within an existing State department. Regardless of where the Board is placed, it is important that the statutory authority flow directly to it and that it have independent powers of operation.

In cases where the Board is placed in an existing State department, it is suggested that it be placed within the State health department because of the close connection between the work of the State health department and water pollution control activities. Further, State health departments in most cases are already active in the field of water pollution control and have trained technical staffs working on pollution control problems.

The "Suggested State Water Pollution Control Act" may be adapted to the placing of water pollution control authority within the State health department by inserting the words "in the State health department" after the word "established"; virtually no other change will be necessary.

[5] This list of members of the Board is suggestive only and is not meant to be inclusive. The membership of the Board will necessarily vary from State to State. In addition to those mentioned above, some States may desire to place members on the Board for specified terms who are representatives of such fields as public affairs, recreational and resort interests, and broad water resources activities.

Each ex-officio member of the Board may, by official order filed in his respective department, designate a deputy in his department to perform the duties of the member making the designation. Such persons, if any, designated pursuant to this section, shall have the powers and be subject to the duties and responsibilities of the officer appointing him.[6]

No additional compensation shall be allowed any member of the Board[7] for services rendered in that capacity. Actual and necessary travel and other expenses incurred by members in the discharge of their official duties as members of the Board shall be paid out of any funds which are or may become available for the purposes of this Act.

The Board shall organize and annually select one of its members to serve as chairman and one of its members to serve as vice-chairman, shall hold at least four regular meetings each calendar year and shall keep a record of its proceedings which shall be open to the public for inspection. Special meetings may be called by the chairman, and must be called by him upon receipt of a written request therefor signed by two or more members of the Board. Written notice of the time and place of each meeting shall be delivered to the office of each member of the Board and the executive secretary. A majority of the members of the Board shall constitute a quorum.

The Board shall appoint an executive secretary[8] who shall direct and carry out all water pollution control activities vested in the Board. Such executive secretary shall be a person fully trained and experienced in the field of water pollution control and if the Board so desires, may be a present employee of the State government. The executive secretary in the interim between meetings of the Board shall have authority to perform in the name of the Board all functions and duties of the Board except the authority to adopt and promulgate standards, rules and regulations; classify streams; revoke permits; and issue or modify orders.

6/ It may be necessary in some States also to provide that: "Such designation shall be deemed temporary only and shall not affect the civil service or retirement rights of any person so designated."

7/ In States where it is customary to provide an honorarium for members of State Boards and Commissions, similar allowances should be made for those members of the State water pollution control board who are not serving in an ex-officio capacity.

8/ It may be necessary to include a statutory provision for the salary of the executive secretary, if the State statutes do not provide an overall compensation system for State officials.

(ALTERNATE SECTION 3)

Section 3. Creation and Organization of Agency and Advisory Board; Meetings, Employees. (a) There is hereby created and established[9] a State water pollution control agency[10] hereinafter referred to as the "Agency."

(b) The Governor shall appoint an administrator who shall be the head of the Agency, shall perform all functions and duties given to the Agency under this Act, and shall direct and carry out all water pollution control activities vested in the Agency.[11] Such administrator shall be a person fully trained and experienced in the field of water pollution control and if the Agency so desires may be a present employee of the State government.

(c) The Agency may employ, compensate, and prescribe the powers and duties of such officers, employees, and consultants in accordance with the laws of the State as may be necessary to carry out the provisions of this Act. However, technical, legal or other services shall be performed, insofar as practicable, by personnel of the department of health and by other State departments, agencies, and offices.

9/ The State water pollution control authority may be set up as an independent Agency or may be established within an existing State department. Regardless of where the Agency is placed, it is important that the statutory authority flow directly to it and that it have independent powers of operation.

In cases where the Agency is placed within an existing State department, it is suggested that it be placed within the State health department because of the close connection between the work of the State health department and water pollution control activities. Further, State health departments, in most cases, are already active in the field of water pollution control and have trained technical staffs working on the problem.

The "Suggested State Water Pollution Control Act" may be adapted to the placing of water pollution control authority within the State Health Department by inserting the words "in the State health department" after the word "established"; virtually no other change will be necessary.

10/ It may be desirable to modify this type of Agency by making provision for a Review Board to review the final orders of the single administrator.

11/ It may be necessary to include a statutory provision for the salary of the administrator, if the State statutes do not provide an overall compensation system for State officials.

(d) The Administrator may delegate to the executive secretary, officers, employees, and consultants of the Agency such functions and duties as are vested in the Agency by this Act, except the authority to adopt and promulgate standards, rules and regulations; classify waters; revoke permits; and issue or modify orders.

(e) There is hereby established within the Agency a State Water Pollution Control Advisory Board consisting of ___ members. Such members are to be appointed by the Governor for terms of ___ years or until successors shall be appointed or qualified,[12] and shall consist of the Administrator of the State water pollution control agency who shall be chairman, and persons experienced in the fields of public health; agriculture; conservation, fish and wildlife; political subdivisions; and industrial activities.[13] The Water Pollution Control Advisory Board shall hold at least two regular meetings each calendar year. It shall be the duty of the Board to review the policies and program of the State water pollution control agency as developed under authority of this Act and to make recommendations thereon to the Administrator of the Agency.

No compensation shall be allowed any members of the Board[14] for services rendered in that capacity; however, actual and necessary travel and other expenses incurred by members in the discharge of their official duties as members of the Agency shall be paid out of any funds which are or may become available for the purposes of this Act.

Section 4. Powers and Duties. The Board[15] shall have and may exercise the following powers and duties:

(a) To develop comprehensive programs for the prevention, control and abatement of new or existing pollution of the waters of the State;

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[12] Provision should be made for overlapping terms of office for the members of the Advisory Board.

[13] This list of members of the Advisory Board is suggestive only and is not to be deemed to be inclusive. The membership of the Board will necessarily vary from State to State and may include ex-officio members.

[14] In States where it is customary to provide an honorarium for members of State Boards and Commissions, similar allowances should be made for those members of the State Water Pollution Control Advisory Board who are not serving in an ex-officio capacity.

[15] The word "Board" is used throughout subsequent sections of the Act. Where alternate section 3 is selected, the word "Board" should be changed to "Agency."

(b) To advise, consult, and cooperate with other agencies of the State, the Federal Government, other States and interstate agencies, and with affected groups, political subdivisions, and industries in furtherance of the purposes of this Act;

(c) To accept and administer loans and grants from the Federal Government and from other sources, public or private, for carrying out any of its functions;

(d) To encourage, participate in, or conduct studies, investigations, research and demonstrations relating to water pollution and causes, prevention, control, and abatement thereof as it may deem advisable and necessary for the discharge of its duties under this Act;

(e) To collect and disseminate information relating to water pollution and the prevention, control and abatement thereof;

(f) To adopt, modify or repeal and promulgate standards of quality of the waters of the State and classify such waters according to their best uses in the interest of the public under such conditions as the Board may prescribe for the prevention, control and abatement of pollution;

(g) To adopt, modify, repeal, promulgate and enforce rules and regulations implementing or effectuating the powers and duties of the Board under this Act;

(h) To issue, modify or revoke orders (1) prohibiting or abating discharges of wastes into the waters of the State; (2) requiring the construction of new disposal systems or any parts thereof or the modification, extension or alteration of existing disposal systems or any parts thereof, or the adoption of other remedial measures to prevent, control or abate pollution; and (3) setting standards of water quality, classifying waters or evidencing any other determination by the Board under this Act;

(i) To review plans, specifications or other data relative to disposal systems or any part thereof in connection with the issuance of such permits as are required by this Act;

(j) To issue, continue in effect, revoke, modify or deny, under such conditions as it may prescribe, to prevent, control or abate pollution, permits for the discharge of wastes into the waters of the State, and for the installation, modification or operation of disposal systems or any parts thereof;

(k) To exercise all incidental powers necessary to carry out the purposes of this Act.

Section 5. Prohibitions. (a) It shall be unlawful for any person to cause pollution as defined in section 2 (a) of this Act of any waters of the State or to place or cause to be placed any wastes in a location where they are likely to cause pollution of any waters of the State. Any such action is hereby declared to be a public nuisance.

(b) It shall be unlawful for any person to carry on any of the following activities without first securing such permit[16] from the Board, as is required by it, for the disposal of all wastes which are or may be discharged thereby into the waters of the State: (1) the construction, installation, modification or operation of any disposal system or part thereof or any extension or addition thereto; (2) the increase in volume or strength of any wastes in excess of the permissive discharges specified under any existing permit; (3) the construction, installation, or operation of any industrial or commercial establishment[17] or any extension or modification thereof or addition thereto, the operation of which would cause an increase in the discharge of wastes into the waters of the State or would otherwise alter the physical, chemical or biological properties of any waters of the State in any manner not already lawfully authorized; (4) the construction or use of any new outlet for the discharge of any wastes into the waters of the State.

The Board under such conditions as it may prescribe, may require the submission of such plans, specifications and other information as it deems relevant in connection with the issuance of such permits.

Section 6. Classification of Waters; Standards of Water Quality. (a) In order to effectuate a comprehensive program for the prevention, control and abatement of pollution of the waters of the State, the Board is authorized to group such waters into classes according to their present and future best uses for the purpose of progressively improving the quality of such waters and upgrading them from time to time by reclassifying them, to the maximum extent that is practical and in the public interest. Standards of quality for each such classification consistent with best present and future use of such waters may be adopted by the Board and from time to time modified or changed. 18/

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[16] Some States may wish to validate by statute permits or approval of plans and specifications presently in effect which have been issued by competent State authorities such as the department of health.

[17] Western and Southwestern States should include the construction, installation, modification or operation of irrigation projects.

(b) Prior to classifying waters or setting standards or modifying or repealing such classifications or standards the Board shall conduct public hearings in connection therewith. Notice of public hearing for the consideration, adoption or amendment of the classification of waters and standards of purity and quality thereof shall specify the waters concerning which a classification is sought to be made or for which standards are sought to be adopted and the time, date, and place of such hearing. Such notice shall be published at least twice in a newspaper of general circulation in the area affected and shall be mailed at least twenty days before such public hearing to the chief executive of each political subdivision of the area affected and may be mailed to such other persons as the Board has reason to believe may be affected by such classification and the setting of such standards.

(c) The adoption of standards of quality of the waters of the State and classification of such waters or any modification or change thereof shall be effectuated by an order of the Board which shall be published in a newspaper of general circulation in the area affected. In classifying waters and setting standards of water quality or making any modification or change thereof, the Board shall announce a reasonable time for persons discharging wastes into the waters of the State to comply with such classification or standards, unless such discharges create an actual or potential hazard to public health.

Any discharge in accord with such classification or standards shall not be deemed to be pollution for the purposes of this Act.

Section 7. Proceedings before Board. (a) Whenever the Board determines there are reasonable grounds to believe that there has been a violation of any of the provisions of this Act or of any order of the Board, it may give written notice to the alleged violator or violators specifying the causes of complaint. Such notice shall require that the matters complained of be corrected or that the alleged violator appear before the Board at a time and place specified in the notice and answer the charges complained of. The notice shall be delivered to the alleged violator or violators in accordance with the provisions of subsection (e) of this section not less than ____ days before the time set for the hearing.

18/ States which adhere to the "prior acquisition doctrine" should take cognizance of the effect that classification will have on water rights established under other laws.

(b) The Board shall afford an opportunity for a fair hearing in accordance with the provisions of section 8 to the alleged violator or violators at the time and place specified in the notice or any modification thereof. On the basis of the evidence produced at the hearing the Board shall make findings of fact and conclusions of law and enter such order as in its opinion will best further the purposes of this Act and shall give written notice of such order to the alleged violator and to such other persons as shall have appeared at the hearing and made written request for notice of the order. If the hearing is held before any person other than the Board itself, such person shall transmit the record of the hearing together with recommendations for findings of fact and conclusions of law to the Board which shall thereupon enter its order on the basis of such record and recommendations. The order of the Board shall become final and binding on all parties unless appealed to the courts as provided in section 11 within ___ days after notice has been sent to the parties.

(c) Any person who is denied a permit by the Board or who has such permit revoked or modified shall be afforded an opportunity for a hearing in connection therewith upon written application within ____ days after receipt of notice from the Board of such denial, revocation or modification.

(d) Whenever the Board finds that an emergency exists requiring immediate action to protect the public health or welfare, it may without notice or hearing issue an order reciting the existence of such an emergency and requiring that such action be taken as it deems necessary to meet the emergency. Notwithstanding the provisions of subsection (b) of this section such order shall be effective immediately. Any person to whom such order is directed shall comply therewith immediately but on application to the Board shall be afforded a hearing as soon as possible. On the basis of such hearing the Board shall continue such order in effect, revoke it or modify it.

(e) Except as otherwise expressly provided, any notice, order, or other instrument issued by or under authority of the Board may be served on any person affected thereby personally or by publication, and proof of such service may be made in like manner as in case of service of a summons in a civil action, such proof to be filed in the office of the Board; or such service may be made by mailing a copy of the notice, order, or other instrument by registered mail, directed to the person affected at his last known post office address as shown by the files or records of the Board, and proof thereof may be made by the affidavit of the person who did the mailing, filed in the office of the Board.

Every certificate or affidavit of service made and filed as herein provided shall be prima facie evidence of the facts therein stated, and a certified copy thereof shall have like force and effect.[19]

Section 8. Hearings. The hearings herein provided may be conducted by the Board itself at a regular or special meeting of the Board, or the Board may designate hearing officers who shall have the power and authority to conduct such hearings in the name of the Board at any time and place. A record or summary of the proceedings of such hearings shall be taken and filed with the Board, together with findings of fact and conclusions of law made by the Board. In any such hearing a member of the Board or a hearing officer designated by it shall have the power to administer oaths, examine witnesses and issue in the name of the Board notice of the hearings or subpoenas requiring the testimony of witnesses and the production of evidence relevant to any matter involved in such hearing. Witnesses who are subpoenaed shall receive the same fees and mileage as in civil actions. In case of contumacy or refusal to obey a notice of hearing or subpoena issued under this section, the ________ court shall have jurisdiction upon application of the Board or its representative, to issue an order requiring such person to appear and testify or produce evidence as the case may require and any failure to obey such order of the court may be punished by such court as contempt thereof.

Section 9. Inspections and Investigations; Maintenance of Records. The Board or its duly authorized representative shall have the power to enter at reasonable times upon any private or public property for the purpose of inspecting and investigating conditions relating to pollution or the possible pollution of any waters of the State.

Any authorized representative of the Board may examine any records or memoranda pertaining to the operation of disposal systems. The Board may require the maintenance of records relating to the operation of disposal systems. Copies of such records must be submitted to the Board on request.

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[19] Where not otherwise covered by general provisions of State statutes applicable to all administrative agencies, consideration should be given to covering the following points in the "Suggested Act":

(1) Filing or recording the regulations and orders of the State agency with a designated official;
(2) Making such filing and recording prima facie evidence that all requirements of law have been complied with;
(3) Requiring all courts to take judicial notice of regulations and orders when filed or recorded as prescribed;
(4) Certifying copies.

Section 10. Penalties;[20] Injunctions. (a) Any person[21] who shall violate any of the provisions of, or who fails to perform any duty imposed by, this Act or who violates any order or determination of the

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[20] A number of States provide by statute for penalties, additional to those outlined in section 10, for persons killing fish by polluting the waters of the State. Such a provision appears logical and desirable, since the pollution has, in effect, destroyed property of the State and the person responsible should be liable to pay damages therefor. Such provision has not been included in this "Suggested Act", however, since it is considered more appropriate for inclusion in the conservation laws of the State. If the State wishes to include it in this Act, the following language may be employed:

> "(c) Any person who violates any of the provisions of, or fails to perform any duty imposed by, this Act, or who violates an order or other determination of the Board promulgated pursuant to this Act, and causes the death of fish or other wildlife shall, in addition to the penalties provided in subsections (a) and (b) be liable to pay to the State an additional amount equal to the sum of money reasonably necessary to restock such waters or replenish such wildlife as determined by the Board after consultation with the fish and game commission. Such amount may be recovered by the Board on behalf of the State in a civil action brought in the ______ court."

[21] Where the order is directed against a municipality, the responsible municipal officials would have responsibility for taking steps to comply with it. To enable them to take the necessary action, there must be adequate statutory provision for financing such action by the municipality. Issuance of revenue bonds is a method of financing which has received increasingly broad acceptance in recent years. In those States where such issuance is contingent on a vote of the electors of the municipality, enforcement of the Act would be facilitated by a provision waiving the necessity of such a vote in the case of revenue bonds issued to finance the cost of complying with a final order abating pollution. It is believed that the requirement of such a vote is not appropriate where the legal obligation of the municipality to construct a treatment works or take other remedial action has been established under a statute.

Board promulgated pursuant to this Act shall be guilty of a misdemeanor[22/] and in addition thereto may be enjoined from continuing such violation. Each day upon which such violation occurs shall constitute a separate violation.

(b) It shall be the duty of the Attorney General on the request of the Board to bring an action for an injunction against any person violating the provisions of this Act, or violating any order or determination of the Board. In any action for an injunction brought pursuant to this section, any finding of the Board after hearing or due notice shall be prima facie evidence of the fact or facts found therein.

Section 11. Review.[23/] (a) An appeal may be taken from any final order or other final determination of the Board, by any person who is or may be adversely affected thereby, or by the Attorney General on behalf of the State to the ________ court of the State of the area affected or to the ______ court of (seat of Government). Within 30 days after receipt of a copy of the order, or other final determination, or after service of notice thereof by registered mail, the appellant or his attorney shall serve a notice of appeal on the Agency through its (executive secretary) or (Administrator) provided that during such 30-day period the court may for good cause shown extend such time for not exceeding an additional 60 days. The notice of appeal shall refer to the action of the Board appealed from, shall specify the grounds of appeal, including both points of law and fact which are asserted or questioned by the appellant. A copy of the original notice of appeal with proof of service shall be filed by the appellant or his attorney with the clerk of the court within ten days of the service of the notice and thereupon the court shall have jurisdiction of the appeal.

(b) The appellant and the Board shall in all cases be deemed the original parties to an appeal. The State through the Attorney General or any other person affected may become a party by intervention as in a civil action upon showing cause therefor. The Attorney General shall represent the Board, if requested, upon all such appeals unless

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[22/] If the penalty provided for misdemeanors by general statutes is considered insufficient, the State may wish to strike out the balance of the sentence after "misdemeanor" and substitute the following:

> "and upon conviction thereof shall be punished by a fine of not more than $_____ or by imprisonment for a term of not more than one year or by both such fine and imprisonment. In addition thereto such person may be enjoined from continuing such violation."

[23/] The above appeal procedure is suggestive only. In any particular State such procedures will necessarily be adapted to the existing judicial structure and practice.

he appeals or intervenes in behalf of the State. If the Attorney General or a member of his staff is not available to represent the Board in any particular proceeding, the Board is empowered to appoint special counsel for such proceeding. No bond or deposit for costs shall be required of the State or Board upon any such appeal or upon any subsequent appeal to the Supreme Court or other court proceedings pertaining to the matter.

(c) The appeal shall be heard and determined by the court upon the issues raised by the notice of appeal and the answer thereto according to the rules related to a trial in the nature of an appeal in equity of an administrative determination. All findings of fact by the Board are to be deemed final, unless it is shown that such findings were not supported by substantial evidence produced before the Board at the hearing. In any appeal or other proceeding involving any order, or other determination of the Board, the action of the Board shall be prima facie reasonable and valid and it shall be presumed that all requirements of the law pertaining to the taking thereof have been complied with. A copy of the proceedings before the Board shall be certified to the court in connection with each appeal.

(d) A further appeal may be taken to the Supreme Court of the State in the same manner as appeals in equity are taken.

Section 12. Conflicting Laws. This Act shall not be construed as repealing any laws of the State relating to the pollution of waters thereof or any conservation laws, but shall be held and construed as auxiliary and supplementary thereto, except to the extent that the same are in direct conflict herewith.

Section 13. Existing Rights and Remedies Preserved. It is the purpose of this Act to provide additional and cumulative remedies to prevent, abate and control the pollution of the waters of the State. Nothing herein contained shall be construed to abridge or alter rights of action or remedies in equity or under the common law or statutory law, criminal or civil, nor shall any provision of this Act, or any act done by virtue thereof, be construed as estopping the State, or any municipality or person, as riparian owners or otherwise, in the exercise of their rights in equity or under the common law or statutory law to suppress nuisances or to abate pollution.

Section 14. Severability. If any section, subsection, sentence, clause, phrase or words of this Act is for any reason held to be unconstitutional, such decree shall not affect the validity of any remaining portion of this Act.

Section 15. Short Title. This Act may be cited as the (State) Water Pollution Control Act.

NOTE: Where State law or practice requires that an appropriation authorization or an actual appropriation be made with basic legislation, such provisions should be incorporated into the "Suggested Act."

APPENDIX C

LIMNOLOGICAL STUDIES OF THE NORTH PLATTE RIVER

Limnological studies made on the North Platte River in 1950 had as their main objectives evaluation of effects of various pollutants discharged into the stream, and determination of the roles that different components of the river biota are able to enact under conditions of regulated flow. It is realized that field investigations cover periods of time that are too limited to permit exact knowledge of annual cycles; and it should be understood that some statements arrived at from interpretation of conditions observed during the periods of study would in all likelihood be modified if data covering a period of a year or more were available. Inferences drawn from data on hand are in a measure tentative, and should not be considered conclusive for features in which annual cyclic phenomena are involved. However, the information obtained is quite indicative of conditions prevailing during the periods of study; and major effects of various pollutants are well defined. General limnological characteristics of the stream under present conditions are known from these studies, and may be considered in plans for additional regulation of flow.

GENERAL DESCRIPTIVE FEATURES

The stretch of the North Platte River between Alcova Reservoir, Wyoming, and Lake McConaughy, Nebraska, is rather clearly divided into two major ecological divisions, due in part to topography, and in part to variation in water usage for agricultural purposes. Each of these zones exhibits progressive downstream changes that are to be expected in streams of any sort, but environmental changes wrought mainly by more intensive irrigation along the lower 150 miles above Lake McConaughy make this region quite different from the upper 180 miles between Alcova and Guernsey Reservoirs and the first 10 miles or so below Guernsey Dam. Ecological conditions that are in the main characteristic of the upper stretch end in the vicinity of Whalen, Wyoming; and features that so strongly characterize the lower stream become progressively more evident with distance below Whalen.

The interposition of reservoirs for irrigation storage and hydroelectric purposes disrupts the natural continuity of this stream, and lotic (running water) conditions in several respects virtually begin anew below each dam. This is particularly true of grade of bottom materials. Below Alcova Dam the bottom consists mainly of large stones, and this rocky bottom persists downstream to the Casper, Wyoming, area, with stones becoming increasingly smaller in size. Gravel size is

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attained near Glenrock, Wyoming; and from there on down to Guernsey Reservoir, barring occasional rocky outcroppings, the bottom is formed almost exclusively of sand. Below Guernsey Dam the same pattern of size decrease in bottom materials is evident, with sandy bottoms occupying most of the stream bed from the region of Lingle, Wyoming, on down to Lake McConaughy. Causes for such progressive increases in fineness of bottom materials beginning below each dam lie in excavation to deeper strata for construction of dams, and to great erosive action of water upon stream beds just below dams when large volumes are released from storage.

Variations in limnological features of stream regions below dams are also induced by manners in which water is released from each reservoir. Discharge of surface water results in conditions that differ from those encountered when water comes from near the reservoir bottom, since surface and bottom waters of these lakes differ considerably in chemical composition. The stream below Alcova Dam receives only surface water from the lake above, and this in quantity only during the irrigation season; whereas the stream below Guernsey Dam, due to the presence of the hydroelectric unit, contains a mixture of surface and bottom waters from the lake during irrigation periods, and bottom waters alone that come through the turbines after release spillways are closed. Some leakage occurs under spillway gates at both dams after closure, but flow so produced amounts to little. The hydroelectric unit at Guernsey is not in continuous operation during all seasons of the year, and flow through those turbines is not a constant factor affecting the stream below. Seepage around dams does not appear to affect the stream immediately below each. When flow through dam gates at Alcova is cut off, volume passing down the stream below is reduced to a mere trickle; but a gradual increase in flow occurs with distance downstream, due mainly to entrance of seepage water and tributary inflow. It should not be construed from this statement that the stream below the dam consists at first of a mere rivulet that increases in size, since, in reality, it is a series of large pools connected by low flowing, narrow riffles.

Since flow down the North Platte River is regulated, periods of highest water levels in the upper region are frequently abnormal, i.e., they do not coincide with seasons of greatest precipitation or snow melting. High stages in this stretch usually result from release of water for irrigation during dry months of the year, and low flows occur during periods when water is being stored in the reservoirs. The lower reaches of the river, on the other hand, normally exhibit minimum rates of flow during irrigation seasons, when great volumes are being released from reservoirs, and attain their maximum water levels for the year after releases for irrigation have ceased. This apparently anomalous situation results from irrigation withdrawals that may often deplete the lower stream of more than 95 percent of its volume. Withdrawals have little effect upon water levels in the stream between Alcova and

Guernsey Reservoirs, where volume of flow is mainly dependent upon quantities of water released from Alcova Reservoir. Seepage and tributaries, along with some discharge from industries, maintain flow during non-irrigation seasons. Water levels below Guernsey Dam during the irrigation season depend upon amounts of water released from storage, volume diverted for irrigation, extent of return flow from irrigated lands, and natural drainage into the stream from seepage and tributaries. Agricultural demands affect even the volume resulting from seepage and tributaries; and cessation of withdrawals results in increased volume of natural drainage water in the stream. It appears likely that volume of seepage water is considerably increased by excesses from irrigation that return to the stream through the ground. During the growing season, water is withdrawn above diversion dams and conducted to cultivated lands through a system of canals and ditches. Most water in excess of irrigation needs returns to the river by way of open drains. Such drains appear to vary considerably in character, as will be mentioned later.

In its first, or upper, ecological division, the North Platte River is mainly contained within one channel, with few stretches occurring in which flow is divided among two or three channels. During periods of high flow observed in 1950, the river between Guernsey and Alcova consisted almost entirely of a fairly smooth, rushing layer of water that filled the stream bed from bank to bank. At times of low water stages in 1950, the river from Alcova to Casper consisted of pools that were connected by narrow, shallow riffles. Starting at Alcova with a flow of 10 c.f.s., the river gained in volume to approximately 100 c.f.s. by the time it reached Casper. Flow continued to increase below Casper and amounted to approximately 300 c.f.s. just above Guernsey Reservoir. Municipal wastes from the City of Casper are discharged to the river through several outlets. The Standard Oil Refinery at Casper uses the river as the source of its process water and discharges wastes through multiple outlets. Discussion of the character of these wastes is reserved for a later section. Texaco and Socony-Vacuum Refineries at Evansville, Wyoming, use both well and river water in their processes, and their discharges add slightly to the surface volume of river flow. Conoco Refinery, at Glenrock, uses well water exclusively, and discharges to the river at the rate of approximately 500 gallons per minute.

Below Casper, the river changed somewhat in character during the low flow period observed. Due to slightly greater flow, and to greater erodability of finer grade of bottom materials, long shallow stretches tended to become longer and longer with distance downstream between Glenrock and Glendo. The nature of the bottom in the upper region of the river has been described above, and to that discussion should be added the fact that banks of soda lime sludge from water softening processes in the refineries are scattered through the stream from Casper to east of Glendo, Wyoming.

In the second, or lower, ecological division, the river is usually divided into several channels by small islands or towheads. Several channels frequently anastomose to form two or three, and from these water may again flow out into more numerous, smaller paths. Despite the fact that flow below Whalen never closely approaches the volumes present in the Alcova to Guernsey stretch during irrigation releases, the stream there exhibits no well defined tendency to form pools and riffles, and consists for the most part of smoothly flowing layers of water one to three feet deep during irrigation periods. Water levels rise somewhat after irrigation ceases. The sandy bottom is readily shifted by currents, and establishment of riffles and pools is apparently a rare phenomenon. Continuity of stream processes in this region is frequently broken by canals and ditches carrying water away from the river, and by drains returning unusable portions of diverted water to the stream bed. All in all, the lower North Platte Basin presents a picture of extreme flatness, through which the river meanders in multiple channels.

METHODS OF STUDY

Field trips to the North Platte River occupied the periods of July 5 - 15, August 21 - 29, October 9 - 18, and November 6 -- 11, 1950. During July and August, releases for irrigation were being made from Alcova and Guernsey Reservoirs; but these dam gates were closed in late September and remained closed during October and November. In July and October, studies were limited to the upper region between Alcova and Guernsey. They covered the entire stretch from Alcova to Lake McConaughy in August and were restricted to the region between Torrington, Wyoming, and McGrew, Nebraska, in November. Equipment deficiencies prevented measurements of turbidity in July, and a depth sampler was not available during that period. Analyses were according to Standard Methods for the Examination of Water and Sewage, 9th Ed., 1946. Plankton samples of 12 liter volume were concentrated to 60 ml in a Wisconsin type plankton net of No. 20 bolting cloth and preserved with formalin. Bottom organisms were collected with a net (not Surber type) of No. 6 grit cloth from an area of 10 square feet. Periphyton samples were qualitative, and were scraped from stones and other submerged objects with a knife.

Samples were taken at 21 stream stations between Alcova and Lake McConaughy, and in the lakes just above Alcova, Guernsey, and Kingsley Dams. Certain features of each of these sampling points are given in tabular form in table C-1. Samples were collected in Pathfinder Reservoir, and in the lake and stream below Lake McConaughy, in order to supplement information obtained at the other stations, and to tie in with conditions above and below the stretch under study.

Table C 1. Locations and descriptive features of North Platte River sampling stations.

Sta. No.	Name Location	Distance Below Alcova Dam River Miles	Nearest Tributary(ies) Upstream	Return Flow from Irrigation Above	Type of Situation	Bottom	Approximate Volume Flow cfs		
							July	August	October
1	Alcova Reservoir	-	-	-	Lake	-	-	-	-
2	Alcova Bridge	0.2	-	None	Rapids in low stages	Large rocks and rubble	4840	4510	10
3	At Blue Gulch	4.0	Blue Gulch	None	Rapids all stages	Rocks and rubble	4840	4510	20
4	Govt.Bridge Wyoming Hwy. 220	14.2	Bolton Creek Bear Creek	None	Pool and rapids low stages	Rocky,some mud and sand	4870	4520	40
5	At Cottonwood Creek	27.0	Cottonwood Creek Poison Spring Creek	Insignificant	Pool at low stages	Rocky with boulders	4910	4530	50
6	At Mills, Wyo.	47.7	Wall Creek	Insignificant	Smoothly flowing stream	Mud and sand	4980	4540	99
7	Casper, Wyo.	49.0	Casper Creek	Insignificant	Smooth stretch	Rocks, soda lime sludge	4980	4540	96
8	Mystry Bridge	56.0	Sage Spring Creek	Insignificant	Rapids at low stages	Small stones, soda lime sludge	5000	4540	96
9	Parkerton	70.0	Smith Creek Cole Creek	Down Smith Creek	Rapids at low stages	Gravel and sand soda lime sludge	4950	4510	125
10	Glenrock	76.4	Cole Creek	None in immed.vic.	Pool at low stages	Sand and gravel	4930	4500	135
11	Carey Hurst	85.0	Sand Creek	From local lands	Riffle at low stages	Sand	4900	4480	155
12	Bridge 2 miles below Douglas	120.0	LaPrele Creek Fetterman Creek	From LaPrele Creek Project	Riffle at low stages	Sand	4780	4400	225
13	Orin Junction	137.0	Indian Creek	LaBonte Creek Proj	Riffle at low stages	Sand	4740	4480	270
14	Bridge East of Glendo	158.5	Willow Creek	Small local areas	Pool at low stages	Rocks,sand,soda L.sludge	4730	4580	330
15	Guernsey Reservoir	188.5	Broom Creek	-	Lake	-	-	-	-
16	Guernsey Bridge	192.5	-	None	Rapids	Rock and gravel	-	4540	-
17	Ft. Laramie Bridge	209.0	Cottonwood Creek	Drain just above	Rapids	Rock and gravel	-	364	-
18	Henry, Nebr.	243.0	Box Elder Creek	2 drains	Smoothly flowing stretch	Sand	-	1040	-
19	Scottsbluff	268.2	Winter Creek	Local drains	Smooth stretch	Sand	-	1060	-
20	Minatare	276.5	None near	Gering drain	Smooth stretch	Sand	-	1270	-
21	Bridgeport	300.5	Canals only in immediate vicinity	Small drains	Smooth stretch	Sand	-	1630	-
22	Broadwater	315.0	Brown's Creek	Small drains	Smooth stretch	Sand	-	1690	-
23	Oshkosh	345.0	Rush Creek	Small drains	Smooth stretch	Sand	-	1820	-
24	Lewellen	357.2	-	-	Smooth stretch	Sand	-	2060	-
25	Lake McConaughy	382.5	-	-	Lake	-	-	-	-
26	Lake Ogallala	382.3	-	-	Lake	-	-	-	-
27	Keystone	389.5	-	None	Rapids	Sand	-	-	-

PHYSICAL FEATURES

Turbidity

Turbidity and temperature measurements may be found in appendix F. In August turbidity showed a progressive downstream build-up below each reservoir. Quantities of silt in suspension were greatest in the lower region above Lake McConaughy. In October the upper river exhibited turbidities that were below the lower range of the Jackson turbidimeter except just below the Standard Oil Refinery at Casper. Materials responsible for the increase there were quickly dropped from suspension and affected water turbidity for only a short distance below Station 7. Turbidity of the upper river in July, although not measured, was evidently greater than in August. In August turbidity affected light penetration mainly in the lower stretches of the river.

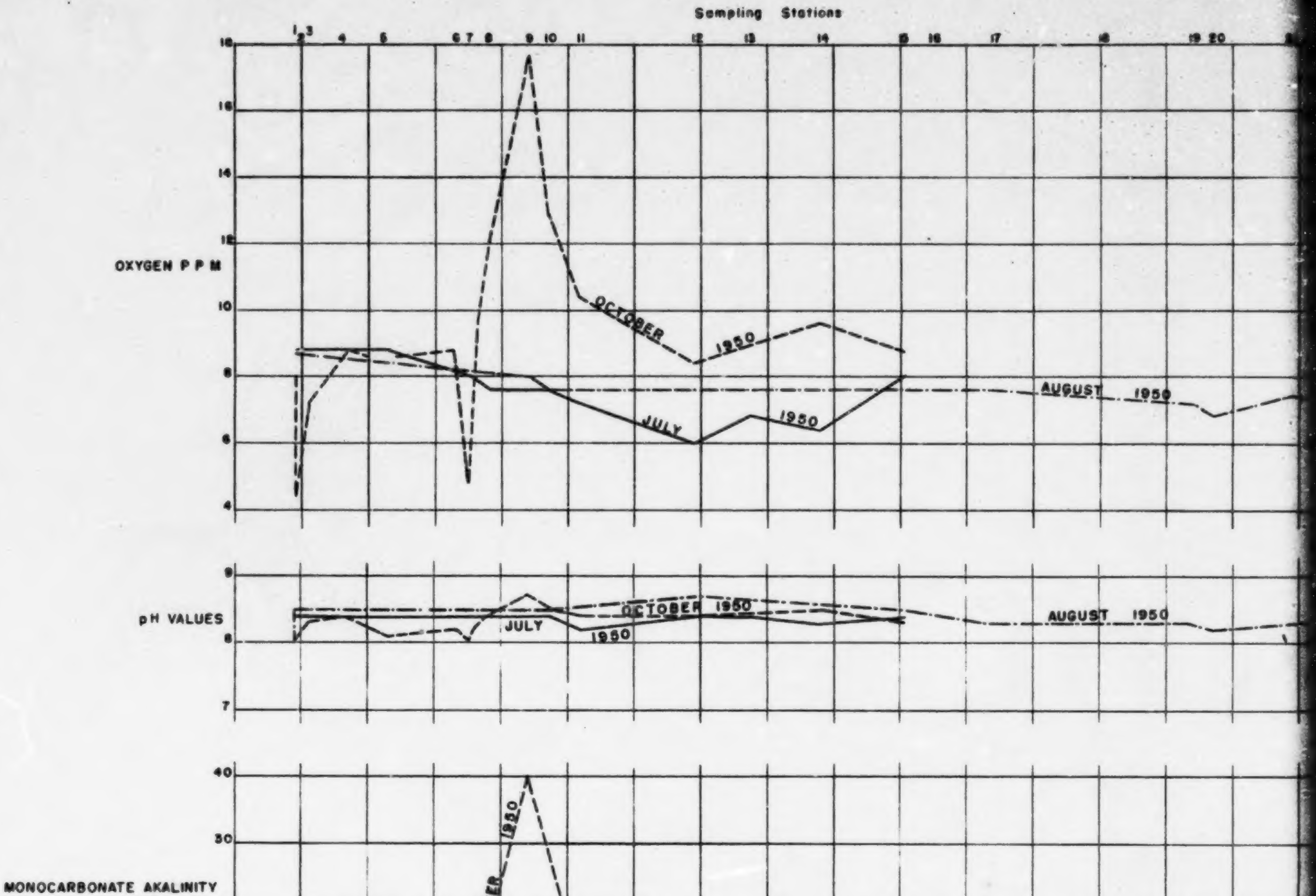
Temperature

Water temperatures were taken only in October and November. The river from Alcova to Guernsey reservoir exhibited a range of 14 - 24.5° C. in October, variation being induced mainly by the fact that samples were taken at different times of the day and in different divisions (riffles or pools) of the stream. The warmest water was encountered just below Alcova Dam after it had been exposed to the sun's rays while trickling down the spillway. Minimum temperatures of 14° C. occurred at Stations 1 and 14. Water temperatures in the Torrington, Wyoming, to McGrew, Nebraska, stretch varied from 1 to 3° C. on November 8 and 9.

CHEMICAL FEATURES

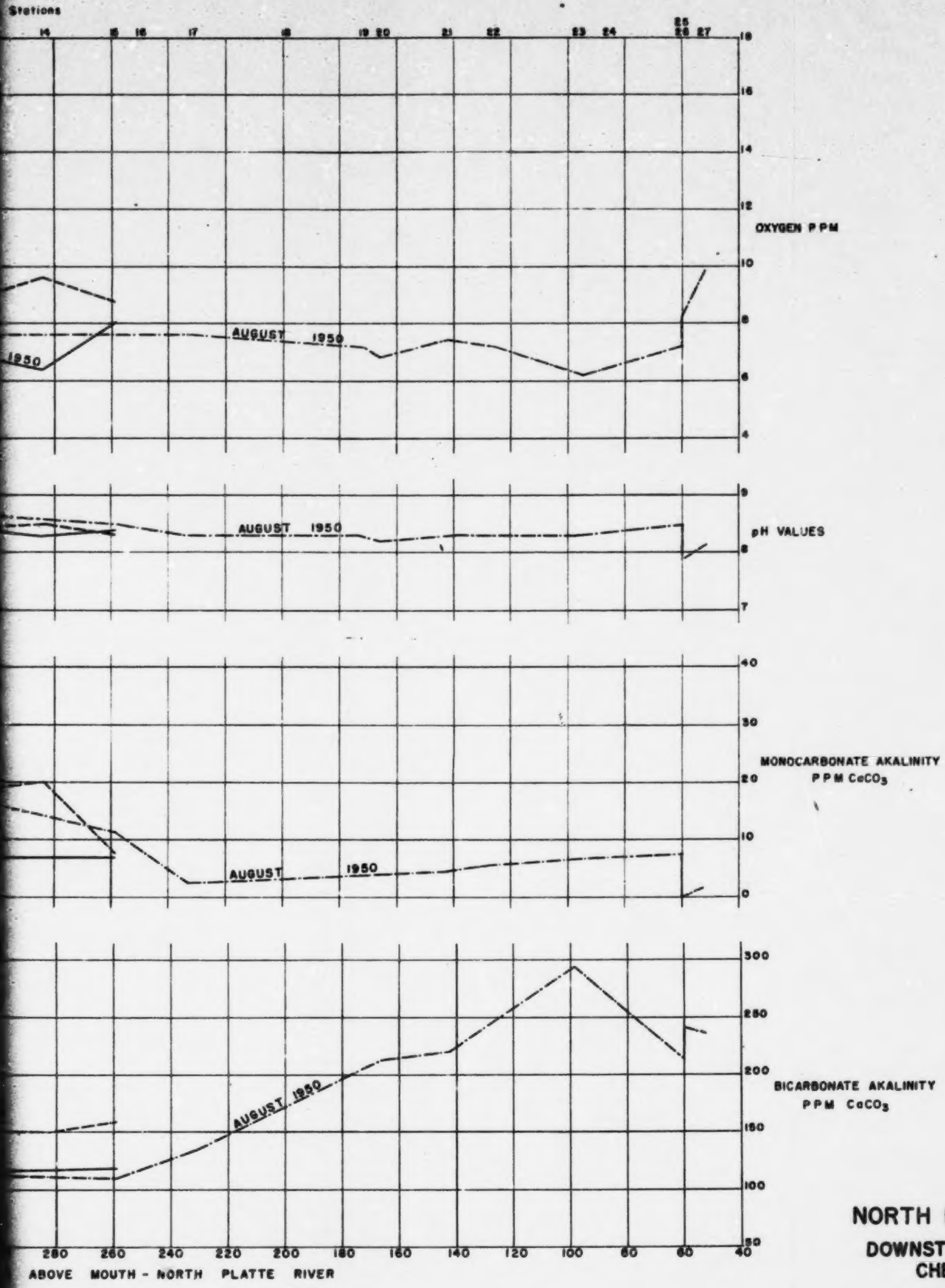
Oxygen

Oxygen content of the water at various stations and during different seasons is shown in Figure C-1. During high water periods, oxygen depletion was nowhere significant in the stretch between Alcova and Guernsey. In July highest oxygen concentrations occurred in Alcova Reservoir and in the upper region of the stream below. There was a slight reduction in the amount of this gas in solution at Casper, a fact which may be attributed to the entrance of municipal and industrial wastes; and a decided drop was evident below Douglas, Wyoming, with some recovery downstream. The fall in oxygen level at Station 12 was noted only in July and evidently was caused by drainage from lands receiving irrigation water from the LaPrele Creek Project. In August the oxygen picture in the upper stretch was much the same as in July, again exhibiting a slight drop below the refinery wastes zone, but remaining level thereafter. Variation occurring in the lower region above Lake McConaughy in August shows influences of return flows from


Sampling Stations
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
OXYGEN P P M
18
16
14
12
10
8
6
4
OCTOBER 1950
JULY 1950
AUGUST 1950
pH VALUES
9
8
7
OCTOBER 1950
JULY 1950
AUGUST 1950
MONOCARBONATE AKALINITY P P M CaCO3
40
30
20
10
0
OCTOBER 1950
JULY 1950
AUGUST 1950
BICARBONATE AKALINITY P P M CaCO3
300
250
200
150
100
50
OCTOBER 1950
JULY 1950
AUGUST 1950
460 440 420 400 380 360 340 320 300 280 260 240 220 200 180 160
MILES ABOVE MOUTH - NORTH PLATTE RIVER

A

FIGURE C-1



NORTH PLATTE RIVER BASIN

DOWNSTREAM AND SEASONAL CHEMICAL VARIATION

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
DIVISION OF WATER POLLUTION CONTROL
1950

B

irrigation, which were augmented in some instances by local thunder showers. Drains in this region varied from clear to rather turbid. Oxygen content was quite high (12.0 p.p.m.) in clear drains due to photosynthesis by benthic algae occurring therein; but in muddy drains it was lower than the least concentration found in the river. Oxygen rise at Lake McConaughy and below represented recovery in the reservoir and increased photosynthesis in the lake (Lake Ogallala) and river below. During low flow in October, oxygen concentrations between Alcova and Guernsey Reservoirs exhibited many variations that were largely due to normal processes occurring within the stream. The low oxygen value obtained at Station 2 (60 percent saturation) represented depletion by respiration of great numbers of fish that crowded the pool just below the spillway at Alcova Dam. Oxygen recovery below was rapid (110 percent saturated at Station 4) below until the second decline - due to entrance of wastes from the Standard Oil Refinery - occurred at Casper. The supersaturated condition found just below Station 7 arose, just as did supersaturated values above Casper, from photosynthetic activity of benthic (bottom dwelling) algae. Just below Casper the stream bed was covered by very luxuriant growths of diatoms and blue-green algae. The values shown in figure C-1 represent samples taken during daylight hours. Samples taken between 11:00 P.M. and 1:00 A.M. at Stations 8, 9, 10 and 11, showed oxygen levels slightly below saturation; and further depletion doubtlessly occurred before the reappearance of light. The loss of oxygen, to values approaching saturation, that occurred below Station 10 during daylight hours was occasioned by turbulence on the shallow stretches from Station 11 to Station 13, where algal growths were considerably reduced. Reappearance of algal growths just above Station 14 was reflected by increased oxygen content of water at that point. With the exception of the region just below Alcova Dam, and the stretch just below the oil refinery at Casper, oxygen values all along the stream were supersaturated for the altitude and temperature.

Hydrogen Ion Concentration

Values of pH were fairly consistent at the first 15 stations in July and August. The slight increase in hydrogen ion concentration evident below Glenrock was probably due to entrance of organic refinery wastes, since it was accompanied by declines in oxygen content and phenolphthalein alkalinity. Recovery was rapid, as may be noted in figure C-1. Slightly lower pH values occurred in the lower ecological division in August, but a decrease in hydrogen ion concentration began shortly above Lake McConaughy and attained its minimum in surface waters of that reservoir. Decreased pH values, or higher hydrogen ion concentrations, below Lake McConaughy were due to release of anaerobic water from the bottom of the lake. Products contained in this water enhanced the development of photosynthetic organisms in the smaller lake and river below, and their food manufacturing processes quickly altered pH, oxygen, and alkalinity values in the manners shown in

Figure C-1 after the water had flowed but a short distance down the river below Lake Ogallala.

During the October low water stages in the upper division, pH varied in accord with the dominant biological process that occurred at each station. It should be borne in mind that hydrogen ion increases, under natural conditions, usually result from respiration of aquatic organisms and decomposition of organic materials, while hydrogen ion decreases, or higher pH values, are occasioned by photosynthesis. Discussion of the chemical reactions involved in these processes is reserved for the section on alkalinity. It may be noted then, in Figure C-1, that lowest pH values occurred just below Alcova Dam, where respiration of many aquatic organisms brought about reduced oxygen quantities as well, and below the Standard Oil Refinery at Casper, where organic wastes were being discharged to the stream. Phenols present in these wastes may also have had a hand in lowering pH; but oxidation of organic components alone could have produced the increased acidity. Below Casper pH values varied in accord with changes in the intensity of the photosynthetic process, as may be noted by comparing pH values and oxygen concentrations in Figure C-1.

Alkalinity

Decomposition and photosynthesis markedly affect the water chemistry as measured by monocarbonate and bicarbonate alkalinity values, and significant variation in them is usually associated with pH changes, as mentioned above. Both decomposition and respiration result in the production of free CO_2, which enters solution to form carbonic acid (H_2CO_3). This acid reacts with monocarbonate (normal carbonate) to produce bicarbonate as follows:

$$CaCO_3 + H_2CO_3 \dashrightarrow Ca(HCO_3)_2$$

Reduction of the quantity of monocarbonate so effected lowers monocarbonate alkalinity and reduces pH. Photosynthesis, when operating in water with pH values of 8.0 and above, removes CO_2 from bicarbonate and produces monocarbonate and water as follows:

$$Ca(HCO_3)_2 \xrightarrow{\underline{\text{photosynthesis}}} CaCO_3 + CO_2 + H_2O$$

The carbon dioxide is used in the food manufacturing processes of the algae concerned, and the normal carbonate content of the water is increased, with bicarbonate being lowered.

Under average conditions, and with pH in ranges exhibited by the North Platte River, alkalinities, pH, and oxygen content rather accurately denote the degree of photosynthesis or decomposition. It should be borne in mind, however, that not all the monocarbonate produced by photosynthesis remains in solution, and reduction of bicarbonate may often be greater than can be accounted for by increase in the monocarbonate content. Also, under certain conditions, usually associated with great flow, pH response to alkalinity changes may sometimes amount to very little.

Monocarbonate Alkalinity

During July, when flow from Alcova Reservoir was approximately 5000 c.f.s., monocarbonate alkalinity of the lake water exhibited an abrupt decline within the first four miles of stream below. Some recovery was evident at a distance of 27 miles below the dam. Variations evident between that point and Guernsey Reservoir seemingly represented depression by the refineries and later recovery. During August, monocarbonate alkalinity was almost uniform in the river from Alcova to Guernsey Reservoir, showed some decline in the latter reservoir, and dropped noticeably below it. The drop below the reservoir was apparently caused by entrance of more acid lake bottom water through turbines of the hydroelectric unit. The progressive build-up of monocarbonate occurring downstream below Guernsey reached its maximum in surface waters of Lake McConaughy. It immediately fell off to 0.0 in Lake Ogallala just below Kingsley Dam, since only bottom water from Lake McConaughy came through the dam. Another increase in monocarbonate alkalinity was evident in the river just a few miles downstream.

In low water stages in October, monocarbonate alkalinity varied in accord with pH and oxygen, being highest where photosynthesis was most pronounced, and lowest where algae were rare or nonexistent.

Bicarbonate Alkalinity

As brought out previously, quantities of bicarbonate are increased by processes in a stream that reduce monocarbonate, and decreased by those that tend to bring about greater monocarbonate alkalinity. It may be noted in figure C-1 that in most instances bicarbonate and monocarbonate curves are diagrametrically opposed. Increase in bicarbonate along with monocarbonate in the lower river in August reflects the general downstream increase in salt content that is usually characteristic of irrigation streams. The sharp decline in bicarbonate that occurred in surface waters of Lake McConaughy was due in part to the fact that stream water flowed through the lake at some distance below its surface. Reduction of bicarbonate in water just below the dam of this reservoir bespeaks the purification wrought by anaerobic processes as water flowed through the reservoir near its bottom. Additional decrease a few miles downstream was evidently due to photosynthetic processes which again produced some monocarbonate in solution. Reduction of bicarbonate in surface waters of the reservoirs results from photosynthesis by plankton organisms, and it seems likely that in the lakes this process is associated with marl deposition, so bringing about a general softening of surface waters.

Bicarbonate alkalinity was considerably higher during low stream stages of October than in high flows of July and August, although it was greatly reduced in the fall by algal growths occurring just below Casper. Great concentration of lake plankton organisms in the river in August was apparently responsible for higher monocarbonate alkalinities.

Phosphate

During the course of biological studies in 1950, phosphate was found in trace amounts only in the region from Casper to slightly below Glenrock. It did not occur, during this period, in the lower region of the stream, not even in drains returning water from agricultural lands. The field kit used for phosphate determinations does not permit accurate calibration of amounts below 1 p.p.m., but does permit recognition of trace quantities. Phosphate in the region just below Casper could have resulted from boiler washings at refineries, or from municipal wastes; and its absence in flow from irrigated fields in the lower river basin may have represented its early use by benthic algae in the drains, its leaching to ground water, or from sampling at periods when phosphate in fertilizer had been exhausted. Analyses made on the lower North Platte River during the summer of 1949 showed phosphate to be present in the river at the several stations listed in appendix F upon only one occasion, June 27. Samples during 1949 covered only limited periods of the year, but indicated something of the ephemeral nature of phosphate in solution.

Nitrogen

Nitrogen cycle analyses were not a part of the limnological program conducted in July, August, and October, 1950. Records kindly supplied by The Chemical and Geological Laboratories at Casper, Wyoming, show that nitrite and ammonia were present at Stations 8 and 10 on March 14, 1949, and that only ammonia was present at Station 9 on the same date. Analyses made by the Water Resources Division - Quality of Water Branch, U. S. Geological Survey, during the summer of 1949 disclosed the presence of considerable quantities of nitrate (up to 7.0 p.p.m.) in the river at Casper. These analyses showed nitrate to be present all along the upper region, and considerable concentrations were noted in well and spring waters in the Glendo area. Refineries discharging into the Casper to Glenrock stretch of the river include ammonia in their waste products (462 pounds daily from Standard Refinery), and oxidation of this ammonia and quantities arising from municipal wastes from Casper probably maintains rather high nitrate concentrations in this section.

Waste Products

In addition to the ammonia mentioned above, oil and phenol were also discharged to the stream by refineries in the Casper to Glenrock region. The oil discharged cannot definitely be tied down to any certain process or processes occurring within the refineries. Its release in significant quantities appears to be only at intervals; and deposits of it left along the river banks by falling water levels are very dark with some other characteristics of crude petroleum. Upon occasion this oil has apparently covered the river surface from bank to bank along considerable stretches of the stream. It is very toxic to fishes and benthic organisms, as will be described below; and it appears likely that its release in such large quantities is usually accidental. The refinery just above Casper has an almost continual discharge of small quantities of oil that have a local effect upon the stream there. Too, rounded patches of a greasy, viscous material sometimes appear on the surface of the water for a distance of several hundred yards below this refinery.

Records supplied by the Water Resources Division - Quality of Water Branch, U. S. Geological Survey, indicate considerable variation in phenol content of river water below Casper, varying from 109 p.p.b. on October 9, 1950, to 1,680 p.p.b. on November 2, 1950. Phenol damage to life in the river is greatest when releases of this waste are in large batches. One refinery releases phenol in the quantity of 30,000 pounds once every 70 days. Effects of this volume of phenol during low water stages are probably severe.

Field trips to the North Platte River have not coincided with discharges of large amounts of the two toxic substances mentioned above, but previous releases of large quantities of oil could be detected from deposits left along both banks of the river upon two occasions. Huge phenol releases could in all likelihood have been ascertained by their influences upon local algal growths had they occurred during the October period of study. Wastes that were released during observations made in July and August had little effect upon the general chemistry of the large volumes of water then in the stream.

A description of sugar beet wastes that are discharged to the lower stretches of the stream in fall and winter may be found in appendix D. The effects of these wastes upon plankton in the river are discussed below.

Chemical features of the lower reaches in November may be found in appendix F. Low water temperature at that time suppressed biological activities to a great extent; and their influences upon water chemistry were not very apparent. Combined discharge of water from all the beet refineries amounted to approximately 62 c.f.s. Loads of pulp and other wastes brought to the river in this water would be expected to alter chemistry noticeably under warmer conditions.

BIOLOGICAL FEATURES

Benthos (Bottom Organisms)

With the exception of algae and microscopic forms included in the periphyton (see later), bottom organisms attained very little development in the North Platte River below Alcova in the period covered by these studies. It was not possible to sample for these forms over much of the river during high water stages, but conditions at those times little favored this element of the stream's biota. Samples that were taken where depth permitted in July and August disclosed the presence of mayfly and stonefly nymphs and chironomid larvae in small numbers in the river above Casper. It was not possible to make bottom samples below Guernsey Dam until considerable quantities of water had been withdrawn for irrigation at Whalen, Wyoming. The rocky stream bed at Ft. Laramie (Station 17) supported a few mayfly and stonefly nymphs along with chironomid larvae, but the sandy bottoms that occurred at Station 18 and below delivered no organisms to the collecting net. The clear water drains in the lower river supported a rather varied benthic assemblage consisting of nymphs of mayflies, dragonflies, and stoneflies, midge and horsefly larvae, and some snails. None of the muddy drains contained any organisms in the 10 square feet of bottom turned up in each.

The low water stages of October permitted sampling for benthic organisms in almost any locality between Alcova and Guernsey Reservoir. Greater variety and concentration of these forms was evident in the river above Casper, where, in addition to forms found in July, snails and planarians were collected. No crustaceans were collected at any station, and, if our failures to find them denote the true state of affairs with regard to this group, the absence of all forms of crustaceans is a striking feature of the benthos over the entire stretch studied. Concentration of benthic forms in the river above Casper varied from 7 to 38 organisms per square foot, with snails and planarians forming about 60 percent, and chironomid larvae about 30 percent of the population. The stretch of stream from Casper to a short distance above Station 14, some 110 river miles, had absolutely no bottom population of its own, when elements assigned to periphyton are excluded. Some aquatic insects and snails occurred in the immediate vicinity of the mouths of some small tributaries at Station 11 and below. The insects in each instance were adult water boatmen and backswimmers, and these forms could conceivably have flown to the sites where found. The absence of larger benthic forms in the region below the refinery area may be laid to the periodic releases of large quantities of toxic wastes from one or more of the refineries. Maximum phenol concentrations in this region of the North Platte River are unknown; however, it appears likely that the blackish oil was more responsible for the dearth of bottom organisms, since it appears rather unlikely that phenol concentrations up to the lethal point would have been able to persist over the entire distance. Some rather crude toxicity tests made in the field showed the oil to be deadly to benthic insects, snails, and planarians that were collected above Casper. It was also lethal when added in very small quantities to a container of water to dragonfly nymphs which were collected below Glendo. It is not known just how often releases of this oil occur, but intervals between them are evidently too short to permit re-establishment of a population of larger benthic organisms. The toxic effects of this oil and/or other refinery wastes are apparently well dissipated by the time water reaches Station 14, as a fairly well developed bottom fauna was evident there in the form of dragonfly nymphs (Hagenius), aquatic hemiptera, planarians, and chironomid larvae. No snails occurred. During periods of high flow, such as occurred in July and August, 1950, such wastes would have less effect, but conditions then appeared to favor very little development of benthos since high flows eradicated riffles, the most productive areas. Bottom forms occurred in shallow water at Station 16 below Guernsey Dam.

Fishes

Information kindly supplied by the Fish and Wildlife Service, U. S. Department of the Interior, and the presence of only brown and rainbow trout, indicate that the North Platte River was not originally a trout stream. This stream formerly supported worthwhile populations of yellow pike perch, sauger, sturgeon, catfishes, buffalo, suckers, and carp.

Equipment for collecting fishes other than small minnows was not available, but in many regions of the stream in October it was possible to determine the presence or absence of fish by observation. Suckers now make up the greater part of the fish population in this river, but carp, trout, and some minnows also occur. During high water periods the only fish in evidence were suckers and carp, which species were often observed feeding upon periphyton growths along the stream margins above Casper and below Glendo. Under low flow conditions there occurred a tremendous concentration of suckers, carp, and trout in the pool just below the spillway at Alcova Dam. This aggregation of fishes affected the chemistry of the water in manners that have been brought out previously. Pools in the stretch between Alcova and Casper contained observable members of the fish population, mainly suckers and carp. In the North Platte these two species appear to depend mainly upon periphyton for food, and are able to attain considerable numbers due to the rather luxuriant growths of benthic algae that occur at various places even under high water conditions. Trout apparently utilize larger benthic organisms and smaller fishes for food. It appears likely that larger trout subsist almost exclusively upon fish. Foraging for bottoms forms must present considerable difficulties to smaller trout during high flow periods.

The region below Casper was devoid of fishes down to the vicinity of Glendo, except for small numbers of minnows near the mouths of some tributaries below Station 11. Fishes noted at Glendo were suckers and small minnows. The latter reacted very quickly to the toxic nature of the black oil under field test conditions. The descent of minnows into the river from tributaries appears to take place between releases of lethal wastes, and in all instances their occurrence was limited to short distances along one bank. Below Guernsey Dam, suckers, carp, and trout were observed down to the neighborhood of Ft. Laramie. In the lower regions fish were seen only in clearwater drains.

Periphyton

The term periphyton has but recently come into any general sort of recognition in this country, and is used to designate that assemblage of mainly microscopic organisms, algae, protozoans, rotifers, microcrustacea, and etc., that form coatings upon rocks, logs, twigs, pilings, and other submerged surfaces. In streams, algae of various sorts usually compose the greater part of such growths. Under more or less normal conditions, periphyton growths on riffles and other shallow regions are mainly responsible for productive levels attained in headwater streams.

Periphyton in the North Platte River varied widely in character over the period covered by field studies in 1950. In July and August its presence was confined to fairly narrow strips along the stream margins in several, but not all, parts of the upper region. It achieved some degree of prominence along the banks just below Alcova Dam, and occurred across the entire width of the stream in the fairly shallow area four miles below. The marginal growths just below Alcova consisted almost exclusively of diatoms, while that occurring farther downstream was based upon Cladophora, among the branches of which were smaller algae, protozoans, rotifers, and other microscopic organisms. Fronds of Cladophora were also noted adhering to bridge substructures, and to various sorts of submerged projections that brought them near the surface, all along the upper river. As evidenced by dried fronds covering rocky bottoms that were bared for a considerable distance below Alcova in October, growths of Cladophora occupied the entire bottoms of many of the shallower stretches of stream before flow was reduced to 10 c.f.s. It may not be absolutely accurate to include Cladophora under periphyton, but since so many of the forms associated with it very aptly deserve that designation, it is convenient to group the entire assemblage of forms together. Cladophora and its associated forms were also prominent in the river below Guernsey Dam down to the region of Lingle, Wyoming.

In October the nature of periphyton had changed somewhat in accord with lower water levels in the region above Casper. Growths of Cladophora and forms inhabiting it were still evident in fair quantities on the riffles, but the pools were characterized by a much shorter growth on stones. This lower growth contained some Cladophora, but consisted mainly of diatoms. Beginning about two miles below Station 7, well within the Casper area, and extending shortly beyond Glenrock, the river bottom was covered by a very luxuriant periphyton growth, which consisted of a mixture of the blue-green alga, *Stigonema*, and diatoms of various species. At Texaco Bridge and at Station 8 the dominant diatom was a small species of *Nitzschia*. At Station 9 a fairly large species of *Synedra* and *Rhoicosphenia curvata* were the most numerous diatoms, and at Station 10 *Rhoicosphenia* greatly outnumbered all others. At Station 11 periphyton was greatly reduced on the sandy bottom, where a thin, brownish film of diatoms occurred in spots. Below Station 11 reduced quantities of periphyton were evident down to shortly above Station 14, where the stream bed cut through a rocky outcropping. Despite the dominant position of the diatom and *Stigoneme* growths, *Cladophora* was still present at almost every station examined, although restricted to widely scattered small patches.

The great abundance of the October periphyton growth in the region immediately below Casper and the oil refinery zone markedly affected the chemistry of the water, as has been brought out previously. The greatly accelerated growth of such organisms in this area represented influences of nitrate and phosphate that were either discharged to the river in refinery and municipal wastes, or oxidized from other compounds that were so discharged. The majority of these algae and associated forms proliferate rapidly under such favorable conditions, and have the ability to recover quickly from various adverse stimuli. Hence, their great abundance in this region may have represented their resistance to the toxic refinery wastes, or their rapid recovery after being decimated by such wastes. It appears likely that at least some reduction in their number was occasioned by the wastes.

No periphyton growth was observed or collected in the main river below Station 17, but considerable quantities were present in clearwater drains of the lower region.

Qualitative aspects of various periphyton growths at the different seasons are as follows:

July

A. Forms associated with *Cladophora*:

Diatoms

1. *Diatoma vulgare* very abundant
2. *Navicula* spp.
3. *Gomphonema* spp.
4. *Mastogloia* spp.
5. *Meridion circulare*
6. *Rhoicosphenia curvata*
7. *Synedra* spp.
8. *Cymbella* spp.

Protozoa

9. *Vorticella* sp.

Rotifera

10. *Lecane* spp.

11. *Lepadella* sp.

Nematoda

12. *Nematoda* spp.

B. Other Periphyton Forms:

Blue-Green Algae

1. *Gomphosphaeria* sp.
2. *Oscillatoria* sp.
3. *Lyngbya* sp.
4. *Dichothrix* sp.
5. *Stigonema* sp.

Diatoms

6. *Diatoma* sp.
7. *Gyrosigma* sp.
8. *Cymatopleura solea*
9. *Cymatopleura elliptica*
10. *Surirella* sp.

Yellow Brown Algae

11. *Tribonema* sp.

Green Algae

12. *Oocystis* sp.
13. *Oedogonium* sp.
14. *Spirogyra* sp.
15. *Hyalotheca* sp.
16. *Pleurotaenium* sp.
17. *Closterium* sp.

Protozoa

18. *Difflugia ureolata*
19. *Difflugia constricta*
20. *Centropyxis aculeata*

Rotifera

21. *Cephalodella* sp.

Tardigrada

22. *Macrobiotus* sp.

Annelida

23. Naididae spp.

August

Diatoms

1. *Synedra* spp.
2. *Gyrosigma* sp.
3. *Gomphonema* sp.
4. *Cymbella* spp.
5. *Navicula* spp.
6. *Mastogloia* spp.

7. *Rhoicosphenia curvata*
8. *Diatoma vulgare*
9. *Diatoma* sp.
10. *Biddulphia* sp.
11. *Rhopalodia gibba*
12. *Cystopleura* sp.
13. *Amphora ovalis*
14. *Amphiprora* sp.
15. *Cymatopleura solea*
16. *Cymatopleura elliptica*
17. *Surirella* sp.
18. *Nitzschia* sp.
19. *Cocconeis* sp.

Blue-Green Algae

20. *Oscillatoria* spp.
21. *Lyngbya* sp.
22. *Stigonema* sp.

Green Algae

23. *Cladophora* sp.
24. *Chaetophora* sp.
25. *Spirogyra* sp.
26. *Hyalotheca* sp.
27. *Closterium* sp.

Protozoa

28. *Difflugia ureolata*
29. *Difflugia constricta*
30. *Arcella* sp.
31. *Centropyxis aculeata*
32. *Euglypha alveolata*

Rotifera

33. *Cephalodella* sp.
34. *Mytilina ventralis*
35. *Lepadella patella*
36. *Lecane lunata*
37. *Lecane luna*
38. *Lecane* sp.

Nematoda

39. Nematoda spp.

October

Diatoms

1. *Cymbella* spp.
2. *Navicula* spp.
3. *Diatoma vulgare*
4. *Diatoma* sp.
5. *Fragilaria crotonensis*
6. *Fragilaria* sp.
7. *Melosira* spp.
8. *Cocconeis* sp.

9. *Rhoicosphenia curvata* Dominant form at Stations 10, 11, and 14;dominant with *Synedra* at Station 9

10. *Synedra* spp. see *Rhoicosphenia*

11. *Gomphonema* sp.

12. *Mastogloia* sp.

13. *Cymatopleura solea*

14. *Pinnularia* sp.

15. *Cystopleura* sp.

16. *Nitzschia* sp. Most abundant diatom at Station 8

17. *Surirella* sp.

Blue-Green Algae

18. *Stigonema* sp. Very abundant at Stations 8, 9 and 10

19. *Lyngbya* sp.

20. *Oscillatoria* spp.

Green Algae

21. *Cladophora* sp.

22. *Hyalotheca* sp.

23. *Closterium* sp.

Protozoa

24. *Arcella* sp.

25. *Centropyxis aculeata*

26. *Difflugia ureolata*

27. *Difflugia constricta*

28. *Vorticella* sp.

29. Holotricha spp.

Rotifers

30. *Lecane* sp.

31. *Colurella colurus*

32. Rotifera sp.

Nematoda

33. *Nematoda* spp.

Plankton (Microorganisms suspended in water)

Qualitative Aspects.

During periods of discharge for irrigation the plankton population of the North Platte River consisted for the most part of a mixture of organisms from plankton of the reservoir lakes with those arising from periphyton on the stream bed. Some members of the river periphyton were also present in similar growths that occurred along the margins of the lakes. This fact makes possible their inclusion in considerable numbers in lake plankton samples unless precautions are taken to prevent the sampler from coming into contact with such growths. Organisms in river plankton arising from lake plankton at the different seasons are listed below. It may be noted that these lists include some of the genera already listed for the periphyton. The lake plankter members of these genera in almost all instances belonged to different species than their periphyton relatives, although some organisms characteristic of lake plankton in July and August occurred in the periphyton in October. Lake plankton species that differed from periphyton species of the same genus, when both were undetermined, are designated by the letter L.

July

In water from Alcova Reservoir

Blue-Green Algae

1. *Anabaena flos aquae*

2. *Oscillatoria* sp. L

Diatoms

3. *Stephanodiscus* sp.

4. *Asterionella formosa*

5. *Fragilaria crotonensis*

6. *Fragilaria* sp.

7. *Tabellaria fenestrata*

8. *Synedra* sp. L

Green Algae

9. *Pediastrum boryanum*

Protozoa

10. *Difflugia globula*

11. *Epistylus* sp.

Rotifera

12. *Keratella quadrata*

Cladocera

13. *Daphnia* sp.

14. *Simocephalus* sp.

15. *Ceriodaphnia* sp.

Copepoda

16. *Cyclops* sp.

17. *Diaptomus* sp.

In water from Guernsey Reservoir

Blue-Green Algae

1. *Microcystis* sp.

2. *Aphanizomenon* sp.

3. *Oscillatoria* sp. L

4. *Anabaena flos aquae*
Lyngbya sp.

Diatoms

5. *Melosira* sp.

6. *Asterionella formosa*

7. *Fragilaria crotonensis*

8. *Tabellaria fenestrata*

9. *Synedra* spp. L

10. *Navicula* sp.

11. *Diatoma* sp.

Green Algae

12. *Pediastrum boryanum*

13. *Gonium pectorale*

Protozoa

14. *Difflugia globula*

15. *Acanthocystis* sp.

16. *Epistylus* sp.

Rotifera

17. *Brachionus* sp.

18. *Synchaeta* sp.

Copepoda

19. *Cyclops* sp.

In August, Alcova and Guernsey Reservoir plankton populations did not differ sufficiently to merit separate listings, and lake plankters in river water from both sources are given below.

Diatoms

1. *Stephanodiscus* sp.

2. *Melosira* spp.

3. *Asterionella formosa*

4. *Fragilaria crotonensis*

5. *Fragilaria* sp.

6. *Tabellaria fenestrata*

7. *Synedra* spp. L

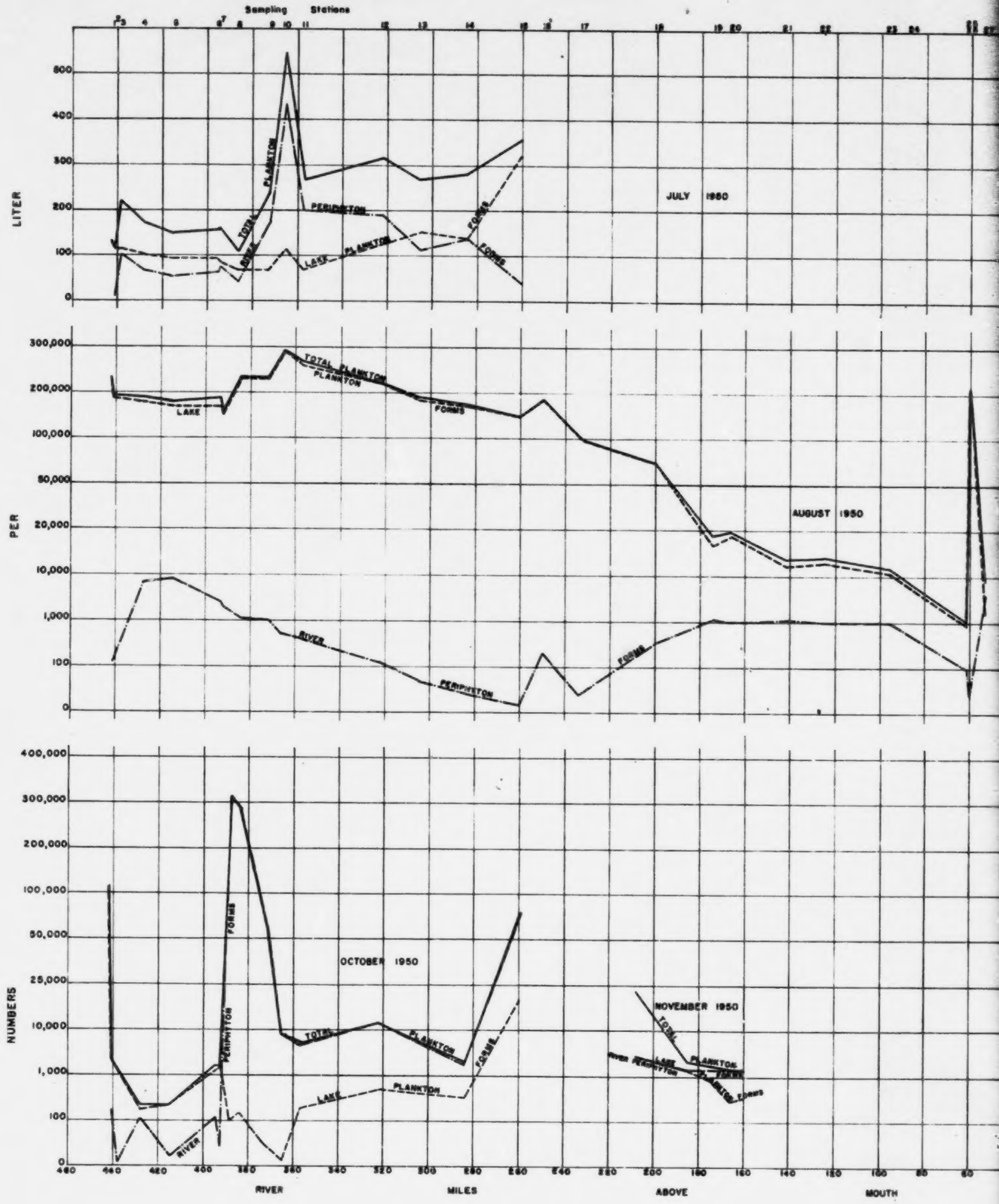
Blue-Green Algae

8. *Anabaena* sp.

9. *Aphanizomenon* sp.

Chrysophyceae

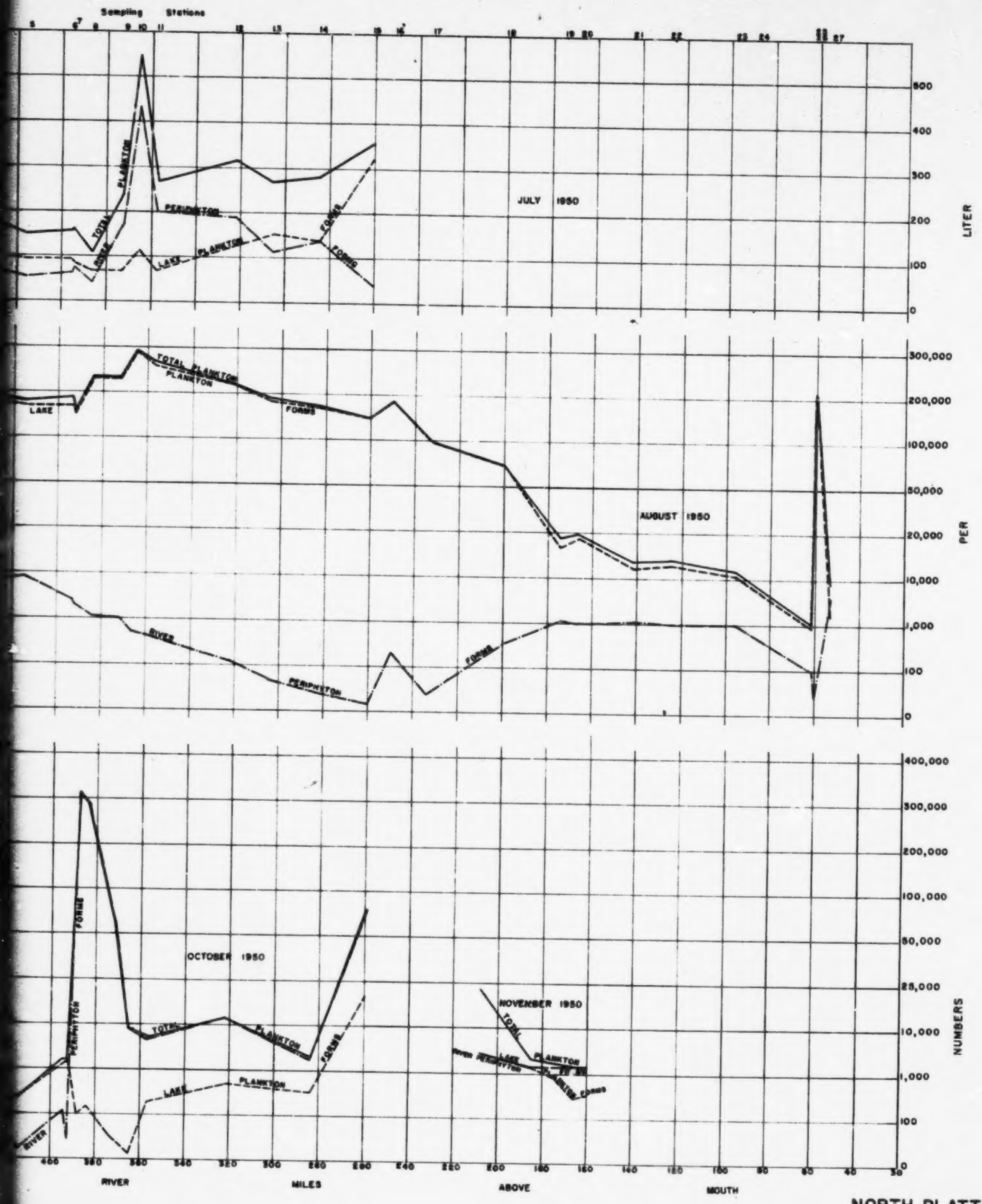
10. *Dinobryon* sp.


Sampling Stations
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
NUMBERS PER LITER
500
400
300
200
100
0
JULY 1950
TOTAL PLANKTON
PERIPHYTON
RIVER FORMS
LAKE PLANKTON
FORMS
300,000
200,000
100,000
50,000
20,000
10,000
1,000
100
0
AUGUST 1950
TOTAL PLANKTON
PLANKTON
LAKE
FORMS
RIVER
PERIPHYTON
FORMS
400,000
300,000
200,000
100,000
50,000
25,000
10,000
1,000
100
0
OCTOBER 1950
FORMS
PERIPHYTON
TOTAL
PLANKTON
FORMS
LAKE
PLANKTON
RIVER
NOVEMBER 1950
TOTAL
LAKE
PLANKTON
FORMS
RIVER PERIPHYTON
FORMS
480 460 440 420 400 380 360 340 320 300 280 260 240 220 200 180 160 140 120 100 80 60
RIVER MILES ABOVE MOUTH

4

122-A

FIGURE C-3



NORTH PLATTE RIVER BASIN

PLANKTON DENSITIES

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
DIVISION OF WATER POLLUTION CONTROL
1950

B

11. *Synura* sp.

12. *Mallomonas* sp.

Green Algae

13. *Pandorina morum*

14. *Pediastrum boryanum*

15. *Pediastrum duplex*

16. *Staurastrum* sp.

Protozoa

17. *Difflugia globula*

18. *Acanthocystis* sp. (Guernsey only)

19. *Epistylus* sp.

Rotifera

20. *Keratella cochlearis*

21. *Keratella quadrata*

22. *Polyarthra* sp.

23. *Triarthra* sp.

24. *Brachionus* sp.

25. *Synchaeta* sp.

Copepoda

26. *Cyclops* sp.

Cladocera

27. *Daphnia* sp.

28. *Bosmina* sp.

Qualitative differences between plankton populations of Alcova and Guernsey Reservoirs were striking in July, but not evident in August. Samples were from surface waters just above the spillways in each lake, and qualitative differences in July were likely due to the fact that water from Alcova Reservoir had not then reached the lower end of Guernsey Lake. The extent to which qualitative aspects of the river plankton were affected by entrance of organisms from the periphyton may be noted in tables C2, C3, and C4. Reference to table C3 should indicate the main qualitative features of plankton in Lake McConaughy, Lake Ogallala, and the river below these two lakes. Plankton populations present in the river in October and November were made up of surviving lake forms and forms entering from the periphyton, as shown in table C4.

Quantitative Features

Over the entire stretch of river studied, plankton concentrations were least in July and greatest in August. In October, great concentrations were evident as a result of certain local conditions, but general levels then were considerably below those attained in August. Reference to tables C2, C3 and C4 will show that there was considerable variation in numbers of certain species over the three periods when samples were taken. For instance, in July the dominant organism among the lake plankter group was *Asterionella*, while in August, *Fragilaria* was present in quantities that greatly outnumbered the total of all other plankters combined. In July, organisms from periphyton made up a considerable percentage of the total plankton population, often outnumbering forms from lake plankton, but were insignificant when compared to lake plankters in August. In October the periphyton forms exhibited great local concentrations in the plankton that surpassed in one instance the greatest density that lake forms attained in August. In August, plankters from the lakes, particularly Fragilaria crotonensis, possessed such a great numerical superiority that changes in river plankton concentrations merely reflected variations in numbers of lake forms.

It has been observed that lake plankters exhibit a decrease in number as they move down streams that drain natural lakes. This response of lake plankters to a stream environment did not characterize their journey down the North Platte River from Alcova to Guernsey Reservoirs. Their densities at various stations down this section of the stream in July, 1950, are shown in figure C2. The gradual decline in numbers evident from Alcova to Station 9 may be regarded as resulting from some deleterious effects of the lotic situation. The increased concentration that occurred at Station 10 was probably in response to enriching materials, such as nitrate and phosphate, that entered the stream in wastes from Casper and oil refineries. The pattern formed by the plankton density curve for stations downstream from No. 10 was substantiated by three series of samples, and has been difficult to understand. Drainage through lands irrigated by water from the LaPrele Creek Project was entering the river above Station 12 at the time, and it is possible that nitrate and/or phosphate was brought into the river in the drainage waters. It is regrettable that analyses for these salts could not be carried out in July.

In August, lake plankter elements of the river plankton exhibited the downstream density pattern shown in figure C2. Down to the region of Station 10 this curve is very similar to the one for July, although variations are much more emphasized by the far greater numbers of organisms. In August, however, the peak concentration attained at Station 10 was followed by a progressive decrease all the way down to Guernsey Reservoir, indicating that factors bringing about increases below Station 12 in July were inoperative during times of sampling in August. Decreased plankton concentrations that occurred in the river below Station 16 represented effects of withdrawals for and return flows from irrigation, as lake plankton forms were practically absent from drains bringing water back to the river. Sharp increases below Guernsey Reservoir and Lake McConaughy were evidently due to enrichment of water caused by oxidation of decomposition materials present in bottom water that flowed from each of these lakes. Slowing of water discharged from Lake McConaughy by Lake Ogallala immediately below, and withdrawal of large volumes of water by the Keystone Diversion Dam just downstream from Station 26, resulted in a sharp localization of effects of enriching materials, insofar as the river itself was concerned. The decline

PLANKTON DATA

NUMBERS PER LITER OF VARIOUS ORGANISMS AT EACH STATION

Table C-2

North Platte River Stations July 1950	Asterionella	Fragillaria		Diatoma vulgare	Cymbella	Navicula		Tabellaria	Diatoma sp.	Stephanodiscus	Anabaena	Oscillatoria	Lyngbya	Stigonema	Aphanizomenon	Pediastrum	Cladophora	Hyalotheca		Difflugia	Centropyxis	Epistylis	Keratella	Synchaeta	Nematoda	Cyclops	Diaptomus	Juvenile Copepoda	Daphnia	Simocephalus	Ceriodaphnia	Chironomidae	Naididae (Annelida)
1	19	3		0	0	0		1	0	1	1	12	0	0		1	0	0		0	0	1	1	0	0	16	23	27	6	1	1	0	0
2	16	2		0	2	2		0	0	2	0	1	1	0		0	0	0		0	1	0	0	0	0	1	7	78	6	2	0	0	0
3	24	1		1	30	17		0	0	4	0	0	1	0		0	4	0		1	2	1	0	0	0	1	4	70	5	0	0	1	0
4	28	1		1	9	15		0	10	3	0	1	1	0		0	24	1		1	3	1	0	0	0	1	7	50	11	0	2	0	0
5	29	1		1	5	11		0	18	2	0	1	1	0		0	12	1		1	4	1	0	0	0	1	8	50	3	0	0	1	0
6	36	3		3	15	15		0	8	1	0	0	0	0		1	19	1		0	3	1	1	0	1	4	4	36	8	0	0	1	0
7	38	3		3	25	10		0	10	1	0	0	2	0		0	26	1		0	1	1	0	0	0	4	1	33	5	0	0	1	0
8	28	0		0	4	11		0	8	1	0	3	1	2		0	11	1		0	2	0	0	0	0	7	6	25	1	0	0	0	0
9	43	1		1	21	75		0	12	0	0	47	2	1		0	6	1		0	3	0	0	0	1	4	0	20	2	0	0	0	0
10	43	5		5	33	158		0	26	3	0	62	5	1		0	6	3		1	2	0	1	0	2	5	1	28	1	0	0	1	0
11	38	2		2	13	95		0	20	3	0	46	3	1		0	2	1		0	3	0	0	0	1	3	1	21	1	0	0	1	1
12	93	4		4	28	83		0	29	0	0	29	5	1		0	4	1		0	3	0	0	0	1	4	3	18	2	0	0	1	1
13	121	10		10	3	23		0	51	2	0	15	8	0		0	3	1		0	3	0	0	0	1	3	2	12	3	0	0	1	1
14	127	6		6	3	24		0	73	1	0	19	11	0		0	2	1		0	4	1	0	0	0	3	0	2	1	0	0	1	0
15	320	3		3	0	4		1	4	1	1	1	1	0	1	1	1			1	0	1	0	2	0	1	0	0	0	0	0	0	0

Table C-3

PLANKTON DATA

NUMBERS PER LITER OF VARIOUS ORGANISMS AT EACH STATION

North Platte River Stations August 1950	Asterionella	Fragilaria	Navicula	Cymbella	Diatoma vulgare	Melosira	Pandorina	Tabellaria	Synedra	Stephanodiscus	Diatoma sp.	Gyrosigma	Biddulphia	Oscillatoria	Anabaena	Lyngbya	Aphanizomenon	Stigeoma	Dinobryon	Synura	Pediastrum	Cladophora	Difflugia	Centropyxis	Keratella	Polyarthra	Lecane	Brachionus	Lepadella	Nematoda	Cyclops	Diaptomus	Juvenile Copepods	Daphnia	Chironomidae
1	1,270	230,000	15	0	0	60	5	0	90	990	0	0	0	5	0	0	5	0	0	0	0	0	20	0	10	10	0	0	0	0	5	0	30	5	0
2	1,170	190,000	5	100	70	120	0	5	5	580	20	0	0	10	0	5	5	0	0	0	0	5	5	0	5	5	0	5	0	0	5	0	15	10	0
4	890	180,000	3,870	520	3,360	40	0	0	110	630	10	10	0	10	0	5	0	0	0	0	0	5	0	5	5	5	0	0	5	0	0	5	0	0	40
8	1,090	230,000	410	120	770	60	0	0	270	760	5	5	0	170	5	20	60	5	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0
9	1,050	230,000	80	35	500	60	15	0	240	1100	0	0	0	300	0	5	30	20	0	0	0	0	0	25	0	0	0	0	5	5	0	0	0	0	15
10	1,390	290,000	110	30	260	15	0	5	110	880	5	0	0	170	0	15	45	20	0	0	5	0	5	20	0	0	0	0	0	0	0	0	0	0	10
12	1,020	220,000	45	25	110	5	5	0	15	500	10	0	0	40	0	5	80	0	0	0	0	10	0	15	0	0	0	0	0	5	0	0	0	0	5
15	3,680	145,000	0	0	15	10	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
16	3,810	183,000	170	15	20	5	0	5	5	20	5	0	0	45	5	10	30	0	0	0	10	5	5	0	0	0	0	0	0	0	0	0	0	0	15
17	1,520	98,000	10	5	0	0	0	0	0	5	0	0	0	10	0	0	10	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	0
18	1,610	72,500	35	10	5	0	0	0	20	0	0	5	30	15	0	5	5	0	0	0	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0
19	1,400	16,280	660	45	250	35	0	0	410	0	5	55	85	80	5	5	10	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5
20	1,720	17,390	290	0	135	10	0	0	340	0	0	30	90	125	0	0	20	0	0	0	5	0	0	0	0	0	0	0	0	10	0	0	0	0	0
21	1,580	11,120	540	25	140	5	0	0	380	0	20	30	100	155	0	0	0	15	0	0	0	0	0	10	0	0	5	0	0	20	0	0	0	0	0
22	1,420	11,850	350	5	95	20	0	0	370	0	0	35	160	155	0	20	10	15	0	0	5	0	0	10	0	0	5	0	0	0	0	0	0	0	0
23	400	10,830	280	5	40	30	0	0	310	0	20	20	150	135	0	15	5	0	0	0	10	5	5	10	0	0	0	0	0	55	0	0	0	0	0
25	60	950	35	25	25	75	0	0	20	0	0	0	5	20	0	10	0	0	120	0	35	0	0	0	25	0	0	0	0	0	0	0	0	0	0
26	17,340	181,000	40	0	0	14,500	16,470	20	0	0	5	0	10	0	0	0	0	0	560	5	140	0	0	0	530	40	0	0	0	0	15	0	385	10	0
27	260	2,040	50	20	20	40	260	0	2700	0	5	0	0	3750	0	0	0	10	10	0	0	0	0	0	15	0	0	0	0	10	0	0	0	0	0
Ft. Laramie Ditch	1,520	110,000	5	0	0	0	0	0	0	5	0	0	0	5	0	0	10	0	0	0	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Lucerne Ditch	2,480	176,000	95	5	0	5	0	0	0	0	0	0	0	25	5	20	35	0	0	0	10	0	0	5	0	0	0	0	0	0	0	0	0	0	0
N. Morrill Drain	50	1,380	570	40	180	0	0	0	230	0	0	0	30	55	250	5	10	10	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
E. Scottsbluff Drain	75	305	230	25	35	0	0	0	80	0	0	0	0	70	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	5	0	0	0	0	10

Table C-4

PLANKTON DATA

NUMBERS PER LITER OF VARIOUS ORGANISMS AT EACH STATION

North Platte River Stations October 1950	Asterionella	Fragilaria	Nitzschia	Synedra	Rhoicosphenia	Aphanizomenon	Tabellaria	Cymbella	Navicula	Stephanodiscus	Melosira	Diatoma vulgare	Diatoma sp.	Anabaena	Oscillatoria	Dinobryon	Euglena	Spirogyra	Pandorina
1	260	114,620	0	0	0	1,040		0	0	752	12	0	0	2	2	0	0	2	2
2	80	2,590	0	20	0	30		0	0	0	20	0	4	0	10	0	0	0	0
3	0	1,080	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0
4	10	160	0	0	0	0		0	0	0	0	10	0	0	0	0	0	0	0
5	0	290	0	0	1	0		0	0	0	0	10	0	0	0	0	0	0	0
6	0	1,030	0	0	3	0		40	70	0	0	0	0	0	20	0	0	0	0
7	0	1,120	400	0	2	0		0	20	0	0	10	0	0	0	0	0	0	0
Texaco Bridge	0	100	310,000	0	2	0		0	2	0	0	0	0	0	0	0	0	0	0
8	0	160	287,000	0	300	0		0	1	0	0	0	0	0	0	0	0	0	0
9	0	40	2,000	780	62,000	0		0	10	0	0	30	0	0	50	0	0	0	0
10	0	10	100	1,870	6,510	0		60	5	0	0	300	0	0	10	0	0	0	0
11	0	260	10	200	5,890	0		10	4	0	0	420	0	0	0	0	0	0	0
12	0	690	1	440	10,200	0		10	10	0	0	230	0	0	10	0	0	0	0
14		510	0	40	2,540	0		0	20	0	0	60	0	0	0	0	0	0	0
15	14,000	65,000	0	10	0	20		0	50	0	10	30	0	0	0	90	10	0	0
November 1950																			
Torrington	960	3,120	480	1,320			10	420	420		180	1560	180		0			120	
Mitchell	360	1,260	60	300			0	120	120			840	10		10			60	
19	260	660	20	720			0	30	240			290	10		30			50	
20	40	410	50	530			10	20	380			240	0		0			20	
McGrew	20	530	10	600			0	10	300			100	30		10			30	

North Platte River Stations October 1950	Stigonema		Centropyxis	Vorticella	Keratella	Polyarthra	Synchaeta	Lecane	Triarthra	Brachionus	Nematoda	Cyclops	Diaptomus	Juvenile Copepods	Bosmina	Daphnia	Rotifera sp.	
1				0	2	10	20	0	2	40	0	1	20	23	10	11		
2				0	0	30	30	20	0	180	0	0	0	30	20	0		
3				0	0	0	0	0	0	10	0	0	0	0	0	0		
4				0	0	0	0	0	0	100	0	0	0	0	0	0		
5				0	0	0	0	0	0	10	0	0	0	0	0	0		
6				0	0	0	0	0	0	0	0	0	0	0	0	0		
7				0	0	0	0	0	0	10	0	0	0	0	0	0		
Texaco Bridge				110	0	0	0	0	0	0	210	0	0	0	0	0		
8				180	0	0	0	0	0	0	60	0	0	0	0	0		
9				20	0	0	0	0	0	0	10	0	0	0	0	0		
10				20	0	0	0	0	0	0	0	0	0	0	0	0		
11				10	0	0	0	0	0	0	0	0	0	0	0	0		
12				0	0	0	0	0	0	0	0	0	0	0	0	0		
14				0	0	0	0	0	0	0	0	0	0	0	0	0		
15				0	0	40	0	0	0	80	0	0	0	0	0	0		
November 1950																		
Torrington	0		0	0	20					10	20						10	
Mitchell	0		0	0	0					0	10						0	
19	0		20	0	0					0	0						10	
20	10		0	0	0					0	20						70	
McGrew	10		0	30	0					0	10						10	

that occurred below Station 16 was also associated with irrigation practices, as large volumes are diverted at Whalen.

Density of lake plankton forms in river plankton in October is also shown in figure C2. Great concentrations were present in the two reservoirs at that time, but apparently very few organisms were being added to the stream by leakage of water under the spillway gate at Alcova. During the summer considerable numbers of these forms were evidently entangled in periphyton growth on the stream bottom, since many of them were still living there in October. Displacement of these survivors from the bottom undoubtedly affected numbers of lake forms in river plankton. Both lake and periphyton elements of the river plankton were reduced by discharge of sugar beet refinery wastes into the lower river in November.

As shown by the curves in figure C2, periphyton organisms exhibited a tendency to settle out of the plankton shortly after they had been brought into suspension. It may be noted from the tables and figure that some of these organisms occurred in all river plankton samples. This fact indicates their susceptibility to displacement by water currents under average conditions. Great concentrations of these organisms in the plankton indicated great abundance of periphyton on the river bed immediately upstream from the sampling point. Growth of the periphyton on the stream bed is influenced by nutrient materials in solution in the water, but also by depth of water, and the nature of materials composing the river bed. It may be noted in this respect that in some instances materials serving to enhance growth of lake plankter organisms in the river also occasioned greater productivity of periphyton organisms on the bottom. Shallow conditions below Alcova Reservoir and Lake Ogallala favored periphyton growth during high water stages, and its greater abundance on the stream bed at these two localities was associated with greater densities of its organisms in the plankton for short distances below. Advantages in competition for nutrient materials in the water were held by the lake plankton group under most circumstances during high water periods, since greater depth of water was in itself a deterrent to the periphyton group. However, in several cases, local conditions were noted to work to the advantage of both groups. Low water levels in the fall placed periphyton organisms in a position to make the most of their opportunities, and they responded with a very luxuriant growth. Periphyton "strays" then dominated the plankton over long stretches of stream.

Drains

Two general types of drains, muddy and clear, were noted. High turbidities in some drains were due in part to the occurrence of local thundershowers; and it seems probable that most drains are normally fairly low in quantities of suspended particles. It also appears likely that drains from plowed areas are more turbid than those arising in lands devoted to pasture and cover crops. Average conditions found in muddy and clear drains were:

	pH	Monocarbonate Alkalinity	Bicarbonate Alkalinity	Oxygen	Turbidity
Muddy Drains	8.2	9.0 ppm	183 ppm	7.6 ppm	625 ppm
Clear Drains	8.5	12.0 ppm	271 ppm	11.6 ppm	-25 ppm

Differences indicated above could well have been due to filling of some drains with rainwater, since water in muddy drains was noticeably softer. It is also likely that muddy drains receive some discharge directly from ditches that bear water from the river, and that clear drains receive only excess water from irrigation. This possibility is borne out to a degree by differences in plankton populations of clear and muddy drains shown in table C-3. West Morrill Drain was muddy and East Scottsbluff drain clear at times when sampled. It may be noted that ditches contained considerable numbers of the lake plankton forms; and greater numbers of these organisms in the drain near Morrill attested to its dilution by water directly from an irrigation ditch or canal.

Muddy drains were seemingly unoccupied by larger benthic organisms that were found in clear drains. Clear drains contained large quantities of aquatic vegetation, both algae and flowering plants, and such growths were scarce in the more turbid drains. Plankton, on the other hand, was less concentrated in clear than in muddy drains. These biological differences would appear to indicate that clear drains offer the more stable environment of the two, and that a distinction between clear and muddy drains is reasonably valid. Clear drains are apparently more responsible for the build-up or salts that occur in the lower river.

Ditches and canals were very similar to the river in their chemistry and plankton.

DISCUSSION

The North Platte River, especially the stretch between Alcova and Guernsey Reservoirs, is an unique stream in that big river conditions that become partly established with prolonged periods of high flow alternate at the same localities with conditions characteristic of headwater streams after releases for irrigation have stopped. Transitions from one to the other type of lotic situation are abrupt, since they are occasioned by either opening or closing spillway gates. Headwater streams under natural conditions are, of course, subjected to flooding at certain periods of the year, but in them water levels rather quickly subside to stages that permit occurrence of riffles and pools; and normal productive cycles, with riffles contributing greater quantities of organisms than pools, suffer little interruption. In the upper regulated portion of the North Platte River, prolonged maintenance of high water levels appears to affect rather severely organisms that normally spend part or all of their lives on riffles or rapids. It seems that prolonged annual interferences with their normal modes of life over the years have resulted in reduced concentrations of many riffle dwelling forms of life. Big river features that show a tendency to become established in late summer are brought to an abrupt end when irrigation demands cease. Biological processes characteristic of either stream type probably never realize their full potential. Low productive levels of many larger, slowly maturing organisms, seem to attest to this hypothesis.

Among stream organisms, the periphyton group appears best able to cope with such a changing environment, since it consists for the most part of small, quickly maturing organisms, most of which possess the ability to form resistant stages that carry them over unfavorable periods. Greatest production of periphyton apparently occurs during lower water stages, but many of its organisms achieve considerable development under high water conditions. Vegetarian fishes, which appear to subsist almost entirely upon periphyton in the North Platte, are thus able to maintain their populations under all water conditions. Crowding of these fishes into pools during low water stages results in some reduction of their numbers, however.

Plankton in the North Platte during periods of water releases from the reservoirs may be divided into two distinct classes or organisms according to their origin in either lake plankton or river periphyton. Periphyton organisms are brought into the plankton by erosion of the bottom and tend to settle out again shortly after they are added. Lake plankton organisms survived very well the lotic conditions below their home reservoirs and showed a ready response to materials and conditions that either enhanced or detracted from their numbers. Numerical changes in this group of organisms indicated entrance of substances that would not have been suspected from the routine chemical analyses. Plankton studies in this respect play a very useful role in pollutional surveys, since they can rather sharply define regions that require more intensive sampling. Plankton features may also furnish information that aids materially in interpretation of general stream conditions.

RECOMMENDATIONS

The stretch of the North Platte River between Alcova Dam and Casper, Wyoming, is virtually unpolluted, and its failure to support worthwhile benthic and trout populations is not due to the presence of toxic manmade pollution. Due to the limited period of the year covered by studies on the North Platte it is difficult to arrive at all causes for low productivity of these desirable organisms. The fact that this stretch of stream is filled with large volumes of water released for irrigation over the greater part of the growing season appears to be one of the major reasons, if not the major reason, for this undesirable state of affairs. Eradication of riffle areas that results from large discharges greatly restricts areas for development of larger benthic forms, and so reduces food supplies for young game fish. Periphyton growths are also curtailed by high water levels, but they occur in sufficient magnitude to permit maintenance of a considerable population of rough fishes the year around. Rough fishes apparently serve as the major food supply for large trout. Under present conditions and irrigation demand it appears unlikely that the pattern of flow regulation in this stretch of stream could be altered sufficiently to permit greater production of desirable aquatic organisms. If future installations downstream permit considerable change in the seasonal flow cycle from Alcova Reservoir it would appear advantageous to regulate discharges between a minimum of 300 c.f.s. and a desirable maximum of approximately 600 c.f.s. during spring, summer, and early fall, and release greater volumes only during the colder months.

Establishment and maintenance of a trout fishery in the river between Casper and Guernsey Reservoir depends first upon installation of adequate facilities to prevent releases of toxic refinery wastes, and secondly upon proper regulation of flow. Optimum rate of flow would need be low enough to insure regular occurrence of riffles, and yet sufficiently high to cover the majority of such areas over most of their width. It seems that flow ranges between the desirable maximum and the minimum suggested for discharges from Alcova Dam (300 - 600 c.f.s.) would be adequate to fulfill this need for the stretch concerned.

It is doubtful that the North Platte River from the region of Torrington, Wyoming, to Lake McConaughy, Nebraska, will be able to afford recreational facilities, other than duck hunting, as long as present irrigation practices are continued. Conditions resulting from withdrawals and return flows of water, higher turbidities, salt increase, and the like, combined with shifting bottom, that is produced in part by water usages for irrigation, appear to make this section of the stream highly unsuited to the production of game fishes and their benthic food organisms.

APPENDIX D

INDUSTRIAL WASTES OF THE NORTH PLATTE RIVER BASIN

Introduction

Liquid wastes from industries discharging to streams of the North Platte River Basin in Wyoming and Nebraska during the 60 to 90-day period that the beet sugar plants are operating each fall have a strength greater than that from the sewage of the entire populations of the States of Nebraska and Wyoming. As a result of this seasonal operation, the greatest volumes of the strongest wastes are discharged during a period when the stream flow is low. In addition to the tremendous volume of organic wastes, toxic materials discharged from industry have greatly damaged or eliminated fish life and have adversely affected other water uses in the river reach from Casper to Guernsey Reservoir.

Conclusions

Industries located on the North Platte River are recognizing their responsibility in maintaining a clean stream through this region. The industries will probably greatly reduce the strength and volume of their wastes within the next few years, and will make efforts toward controlling the discharge of toxic materials. Complete elimination of toxic wastes will be necessary to insure a normal biological regimen in the stream. Complete elimination of all the wastes from the stream cannot be anticipated in the near future. The effects of the wastes can be minimized with controlled discharges, treatment of the stronger wastes, elimination of settleable solids, lagooning, reduction of the volume of the wastes, changing the plant processes, and by maintenance of an adequate minimum stream flow.

The strength of the organic industrial waste discharged to the North Platte River while the sugar refineries are operating is estimated at 1,950,000 population equivalents. If plans for the elimination or control of wastes can be brought into operation, conditions on the North Platte River can be expected to improve greatly over those noted during the past several years.

Survey Methods

In order to become familiar with each of the industries on the North Platte River, arrangements were made with the industries by the State Water Pollution Control Agency concerned for a representative of the Missouri Drainage Basin Office to conduct a conference and study at each of the industrial plants. This report summarizes the investigations that have been completed for each of the 13 major industries. The management of the plants were very cooperative in providing information. After encouragement by the State Water Pollution Control Agency, some of the industries initiated sampling and testing of waste effluents from their plants in order to learn more about the pollutants produced. Wastes from each process of each industry were evaluated on the basis of production. The sums of the individual processes were totaled, the final figure represented the strength of the plant's wastes. These values were later checked by chemical and biological assays of samples of plant wastes and of the receiving stream above and below the sources of pollution.

Industries in the Basin

There are 13 major industrial plants in the Basin. Of these, six are oil refineries; five beet sugar refineries; one canning plant; and one meat packing plant. The oil refineries are capable of processing approximately 60,000 barrels of oil per day. The sugar plants process approximately 11,000 tons of sugar beets per day. The principal meat packing plant, which primarily processes sheep, has a daily capacity equivelent to about 1,800 hog units. The cannery capacity varies depending upon the type of product being packed.

The oil refineries and the meat packing house operate throughout the entire year. The cannery operates continuously with perhaps only minor interruptions by packing pork and beans and other food products during the seasons vegetables are not harvested. The beet sugar refineries operate 60 to 90 days each autumn, the period of operation being dependent upon the amount of beets available for processing.

All but one of the oil refineries are located in Wyoming, and conversely only one of the sugar factories is located in Wyoming. Nebraska has seven major industrial plants in the vicinity of Scottsbluff; the remaining six industries located in Wyoming are widely dispersed along the stream. The majority of the oil refineries are situated in the vicinity of Casper, Wyoming.

Wastes Produced

Each of the industries has a waste typical of the process and product being handled. Petroleum refinery wastes consist of oil from leaks or spills or oil which may be entrained with the water and passes through the separator, cooling water, spent caustic soda, sodium sulphide, phenols, mercaptans and various materials with which the caustic solutions combine. Beet sugar refineries discharge a waste water which carries "dirt" and beet particles in suspension; pulp screen water; lime from the filter presses; some beet pulp particles with the pulp silo drainage; any sugar which may dissolve during the fluming and washing process or which may be in the spent pulp; wastes from the Steffens process; and other organic materials such as pectins, pentosans, and other organic materials dissolved from the beet. Soluble juices from the food being packed, waste food particles and spoiled vegetables are discharged from the cannery sewer to the river. The meat packing plant discharges blood, paunch manure, some fat, and other wastes.

In table I, which shows the major industries of the North Platte River Basin, the population equivalents based upon B.O.D. are probably the most revealing figures. The wastes discharged by the five beet sugar refineries are greater than the combined populations of Nebraska and Wyoming (table II).

Population equivalents based upon suspended solids are an indication of the silt load from these plants. Total suspended solids from a beet sugar plant represent much of the soil carried into the factory with the beets plus the nonsoluble organic material in suspension. The dirt or silt produces turbidity in the receiving stream which upon settling creates sludge deposits and covers bottom growths used for fish food. The volatile, or organic suspended material may cause the conditions mentioned above and in addition also depletes the oxygen supply, possibly causing odors and interfering with stream purification. Suspended solids from a beet sugar plant is a variable figure since it is based on soil carried in with the beets. A wet or dry season and the type of soil in which the beet was grown may cause the amount of suspended solids to vary. Findings of the Environmental Health Center of the Public Health Service at Cincinnati have been used as a basis for evaluating the suspended solid wastes from beet sugar refineries.

Existing Treatment Facilities

All of the six oil refineries located on the North Platte River have installed separators to separate the oil at their waste outlets. These separators are gravity type and provide a means for skimming the oil from the water. The oil recovered is returned for processing. In some plants poorly designed separators permit considerable oil to escape. In other cases it has been noted that emulsions form between the oil and the water and they prevent gravity separation of the oil permitting oil to pass through the separator and to be discharged to the stream. Later when these emulsions break, the oil forms an iridescent film upon the river. Petroleum chemical treating wastes are also normally discharged through the separator to the sewer. No plant wastes are discharged from Plant No. 1 to the stream (table I). All of the wastes after passing through the separators, are discharged to a large impounding basin. This basin is of sufficient size that the rate of evaporation equals the rate of inflow, and none of the wastes from the refinery reach the North Platte River. At plants 2, 3 and 4 (table I) various means are used to impound some of the wastes from chemical treatment. These are not entirely successful and do not include all of the wastes from each of the plants. As a result, phenols,

Table I. Major industries in the North Platte River Basin

North Platte River Miles	Name of industry	Type of industry	Type of operation	Daily rated capacity	Treatment provided	Estimated population equivalent to stream based on: B.O.D.	S.S.	Type of chemical wastes discharged daily
530	Plant #1	Oil refining	Continuous	20,000 bbls.	Complete[1]	None	None	None
396	Plant #2	Oil refining	Continuous	15,200 bbls.	Separators	40,000[2]	32,000[2]	Oil and phenols
390	Plant #3	Oil refining	Continuous	12,000 bbls.	Separators	14,000	14,000	Oil and phenols
389	Plant #4	Oil refining	Continuous	6,000 bbls.	Separator	6,000[2]	7,000	Oil and phenols
366	Plant #5	Oil refining	Continuous	3,800 bbls.	Separator	6,000[2]	4,500	Oil and phenols
206	Plant #6	Beet sugar ref.	Seasonal	2,800 tons	None	550,000	1,900,000	140 tons lime
184	Plant #7	Beet sugar ref.	Seasonal	1,900 tons	None	170,000	1,400,000	45 tons lime
174	Plant #8	Oil refining	Continuous	2,000 bbls.	Separators	1,200	2,400	Oil and phenols
174	Plant #9	Cannery	Almost continuous	Varies with product being canned	None	Maximum of 4,000	1,000	
173	Plant #10	Beet sugar ref.	Seasonal	2,975 tons	None	650,000	2,200,000	150 tons lime
173	Plant #11	Beet sugar ref.	Seasonal	1,765 tons	None	300,000	1,300,000	90 tons lime
	Plant #12	Meat packing and rendering	Normal	1,800 hog units	None	33,000	11,000	
150	Plant #13	Beet sugar ref.	Seasonal	1,900 tons	None	170,000	1,400,000	45 tons lime

[1] Lagooned - waste does not reach stream.

[2] Based upon laboratory data.

Table II. Sources of major industrial pollution in North Platte River Basin

Type of industry	Population equivalent calculated from: B.O.D.	Suspended solids	Percent of population equivalent contributed: B.O.D.	Suspended solids
Oil Refining	67,000[a]	60,000	3.45	.73
Beet Sugar Refining[b]	1,840,000	8,200,000[c]	94.65	99.13
Canning	4,000	1,000	.20	.01
Meat Packing	33,120	11,000	1.70	.13
Total	1,944,120	8,272,000	100.00	100.00

[a] Does not include estimated 12,000 population equivalents from one oil refinery that keeps wastes from stream by lagooning.

[b] Seasonal operation.

[c] Based upon figures supplied by Environmental Health Center, Public Health Service.

spent caustic, sodium sulphide, mercaptans, and other materials found in chemical treating wastes from petroleum refineries are discharged into the stream.

At the present time the five beet sugar refineries have no equipment installed for treating their wastes.

Methods of Pollution Abatement

Since various strong wastes from these plants originate in some particular portion of the process, it is often possible to separate the stronger wastes from the waste waters carrying little or no pollution, such as cooling and wash water. Ordinarily cooling and wash water constitute the largest volumes of water to be handled in an industry.

Methods for the reduction of the strength of the wastes from the various industries must be worked out with each industry, with special emphasis on the reclamation or recovery of as much material that has market value as is possible. In the process of treating the wastes, by-products are sometimes recovered which may be of sufficient value to cover a part of or all the cost of treatment. Studies have revealed that approximately 80 percent of the biological oxygen demand from a beet sugar refinery is contained in but 15 percent of the wastes. If by removing and treating 15 percent of the wastes the total strength of the wastes can be reduced 80 percent, it would appear that such removal should be considered. At some plants where the Steffens process is in use it has been found profitable to concentrate the Steffens waste and separate from it the glutamic acid which is sold for conversion into other products. In the Steffens process the molasses are treated to remove more sugar. Of the five sugar refineries on the river three include the Steffens process. The two plants which do not have this process sell their molasses to those plants which do. In the beet sugar industry, changes in the process may be necessary to reduce the volume and strength of the wastes. The pulp silo drainage waste which is quite strong can be practically eliminated by installing a pulp dryer to reduce the volume and the strength of the waste. The waste from the diffusion battery can be eliminated or greatly reduced by replacing the diffusion battery with the continuous diffusion process. This change will reduce the volume of the pulp water to about one-third of that from the ordinary battery and the strength of such waste does not appear to be as strong as that from the ordinary battery. There are no continuous diffusion batteries in operation in the plants on the North Platte River. The chemical treating wastes from the oil refineries, relatively small in volume, could easily be impounded and not discharged to the stream. Evaporation would eliminate these wastes.

At the meat packing plant blood and grease can be recovered or intercepted before reaching the sewers. Meat packing plant wastes are amenable to biological type waste treatment as well as chemical treatment, therefore by treatment the strength of such wastes can be greatly reduced. The strength of cannery wastes could be reduced by installing fine screens,and can be eliminated by broad irrigation or lagooning. Methods for the reduction of the strengths of wastes from industry must be developed upon an individual basis. Industry should be encouraged and assisted by the water pollution control agencies to assume its responsibility in maintaining clean streams. Clean streams promote good will toward responsible industry, and provide many benefits for water users.

APPENDIX E

PARTIAL REVIEW OF LITERATURE ON PUBLIC HEALTH ASPECTS OF IRRIGATION WITH SEWAGE POLLUTED WATER[1]

1. Davidson (1), according to Wilson (9), reports an outbreak of typhoid and paratyphoid fever involving 65 cases in North Battleford, Saskatchewan, Canada, during the summer of 1941. Neither milk nor water could be incriminated as the agent of transmission. Inconclusive evidence indicated that the infection was spread by vegetables which were irrigated, and possibly washed, with water from a ditch into which the sewage works discharged its effluent.

2. Chapman (2), stresses the need for treatment of sewage discharged to streams from which water is taken to irrigate market produce. Investigations conducted by the Colorado State Board of Health have shown that vegetables, grown in fields many miles below the source of the pollution, contained large numbers of colon bacilli. In many instances washing could not make them fit for human consumption. Some epidemiological evidence is presented. The death rate for typhoid fever, also for diarrhea and enteritis in infants up to 2 years of age, in Colorado is high when compared to that for the U. S. and several western states. Colorado counties having polluted waters have death rates for the above infections almost twice those of counties in which there is little or no pollution of streams. Maps are presented which show the grossly polluted streams are closely associated with the counties having these higher death rates. Water and milk were not considered the infection source. It was recommended that fruits and vegetables grown under or close to the ground should not be irrigated with sewage polluted water. Although cooking may make eating such vegetables safe, it does not eliminate the possibility of introduction of infectious matter into the kitchen and its transfer to foodstuffs.

3. Lumsden and Anderson (3), in their investigation of the origin and prevalence of typhoid fever in the District of Columbia, found (3a) "a suggestively large portion of the typhoid cases in the District of Columbia had eaten lettuce, celery or strawberries during the 30 days prior to illness." They experienced difficulty in tracing the produce back to its source and therefore considered definite conclusions "not justifiable". They conclude (3b), however, that "In view of the insanitary conditions, particularly in respect to the lack of sanitary privies on farms which supply a large portion of the green vegetables and fruits distributed in Washington, it seems quite probable that those foodstuffs play some part, and for occasional

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[1] Acknowledgment is made of the use of this Review as included in the South Platte River Basin Interim Report and the Kansas River Basin Water Pollution Investigation.

periods perhaps a very considerable part, in the distribution of typhoid-fever infection in the District of Columbia". Furthermore, they recommend (3c), "The enactment of legislation prohibiting the sale or the offering for sale in the District of Columbia of . . . any green garden truck obtained from farms not provided with either sanitary privies or sanitary water-closets".

4. Bundsen (4), reports that following a typhoid outbreak in Chicago, which was eventually traced to oyster infection, special effort was made to determine the sources of certain vegetables, lettuce and watercress, served in hotels and restaurants, where it appeared the majority of cases had contracted the infection. This was found to be impossible; there was no common source for such produce. In connection with the investigation bacteriological examination of fruits, vegetables and watercress was undertaken. E.coli bacteria were found but whether of human or other source was not determined. In one case high coli contamination of lettuce was traced to the ice in which it was packed. Need for greater attention to watercress is stressed. In the discussion of Bundsen's paper Dr. F. C. Johnson, a pediatrician, comments that based on his experience he has "advised not to feed lettuce or celery to children as the possibility of infections being carried by these raw vegetables is really great."

5. In the discussion (5) of Dr. Warrys report of an outbreak of enteric disease involving 110 cases in the borough of Hackney, England, it is noted that a high percent of the cases had partaken of watercress within 3 weeks prior to the illness, and bacteriological examination of beds from which the watercress had been taken showed the presence of sewage organisms, in one case, as high as 50 E. coli bacteria per cubic centimeter of water.

6. An article in the Journal American Medical Association (6) notes the raising of vegetables, frequently eaten raw, on the Paris, France sewage farm and associates the occurrence every year, from July to October, of typhoid fever in Paris with the marketing of these vegetables. "Clauditz found germs, after several days, on green herbs thus treated which a thorough washing could not remove. Dr. E. Marchoux, after an investigation, 'recommended that the kinds of herbs and vegetables that may be grown on sewaged land be established by law.'"

7. The American Society of Civil Engineers' committee on salvage of sewage (7) notes that in 1934 the directors of public health in each of the 48 states and the District of Columbia were asked for information on the extent of sewage use for irrigation. Only 9 states, of the 40 replies received, admitted having experience with sewage irrigation and sewage irrigated crops. Significantly, "four were able to trace illness of an epidemic order to such use, whereas one other stated that cattle, pastured on a raw sewage irrigated field developed poorly and were infested with Cysticercus bovis". At that time (7a)

"Only one of the nine was agreeable to the use of (sewage) treatment plant effluent on vegetables to be eaten raw", and that state prescribed practically potable water standards for such effluent. In summarising the committee states (7b) "Thus it would appear that, except for use upon vegetables to be eaten raw, an effluent from about that afforded by subsidence, trickling filters, and secondary subsidence effecting about 85% reduction in biochemical oxygen demand (B.O.D.) and suspended solids, followed by chlorination, should satisfy health requirements..."

8. Roberts (8) noted 23 of 45 cattle fattened on the Tucson, Arizona, sewage farm were upon slaughtering found infested with the tapeworm, Cysticercus bovis. Since these cattle apparently came from different sources -- they all bore different brands - and such general infestation indicated a source common to all or most of them, it was concluded that the infestation resulted from drinking sewage polluted water.

9. Wilson (9) cites the experience at the Melbourne, Australia, sewage farm where in 1937, 46% of the cattle grazed were found infested with Taenia saginata. The sale of these cattle was banned. During a six month survey of Melbourne(1941-42) 100 cases of human tapeworm infections were treated. He concludes, "In ... any town where large portions of the inhabitants are infested with tapeworm ... sewage and sewage sludge must present a real danger."

10. Under Annotations (10) it is noted that Leptospirosis is essentially an occupational disease. Human infection is acquired through the alimentary tract or by contact with contaminated water or other material. It has occurred "during the last few years among ... sewer workers in London and Glasgow ..., and workers in the beet fields in Ireland, who are probably infected through abrasions of the hands in the same way as are the sugar cane cutters in Queensland".

11. Mills et al. (11) conducted laboratory investigations to determine whether the bacteria penetrated the surface of fruits and vegetables. They found that although bacteria do not penetrate the uninjured surface, they may gain entrance through damaged or decayed surfaces and remain viable for from 7 to 42 days. They also demonstrated that bacteria may persist on the surface of fruits or vegetables kept moist for 15 or more days.

12. Kligler (12) investigated the survival and dispersion of typhoid and dysentery bacilli in soil. These bacteria were recoverable from artificially inoculated moist soil (pH 6.6-7.4) for 70 or more days, but were not recoverable in dry soil on the 20th day. They penetrated to a depth of 2, but not 3, feet in 40 days in relatively porous soil under a 1 to 2 inch head of water.

13. Melick (13) in three outdoor experiments, extending from May to September, isolated typhoid bacteria from garden soil 41, 34 and 35 days after inoculation with typhoid bearing excreta. Under hot house conditions old strains of typhoid bacteria survived for 74 days in garden soil enriched with sterile sewage; fresh strains survived only 49 days. In these experiments typhoid bacteria were found on radishes grown in infected soil 37, 28 and 35 days, and on lettuce after 21 days, after inoculation of the soil. The organism became attached to the surface and was not ordinarily removable by washing.

14. Creel (14) investigated the viability of typhoid bacilli on garden truck. He reports 3 experiments in which radishes and lettuce were raised on soil sprinkled with a fecal emulsion mixed with 24-hour old culture of typhoid bacilli 2 or 3 days after the planting.

He states, "that plants cultivated in contaminated soil will take up on the leaves and stems, as they grow through the soils, organisms existing therein."

"The Bacillus typhosus (typhoid bacillus) was recoverable from the tips of leaves that were, to the naked eye, free from soil" and that when these vegetables were grown under natural conditions (except for the artificial inoculation of the soil) the infectious material could be isolated from the leaves up to 31 days.

"Rainfall will not free the vegetables from the infected material".

15. According to Melick (13) "Morse (15) attributed 49 typhoid cases among inmates of an insane asylum to the eating of celery." Typhoid cases had occurred in the institution a few months previously, the celery bed received the institutions sewage, and the epidemic occurred soon after the first use of the celery.

16. According to Melick (13) "Picley (16) records 2 cases of typhoid from eating uncooked rhubarb, which was grown on soil known to be fertilized with typhoid bearing excreta."

17. Veatch (17a) in discussing the Denver, Colorado sewage disposal problem notes that on certain days the Denver sewage accounts for 97% of the flow of the South Platte River, which is used for irrigation immediately downstream. He refers to the construction at Denver in 1937 of a sewage treatment plant which included "fine grained rapid sand filters to secure a high rate of removal of suspended solids and incidentally the removal of ... the encysted type of amoeba (Endamoeba histolytica) which is strongly suspected of being responsible, through the medium of sewage irrigated vegetables, for a considerable amount of sickness in this area." (Abstractor's note: The magnetite filters referred to did not operate satisfactorily and their use was discontinued.)

18. Tanner (18) points out that missed cases and carriers may always be present and that sewage should always be regarded as containing infectious organisms. The work of several investigators is cited and Tanner concludes that (18a) "Sufficient data ... have been recorded to justify the conclusion that polluted soil may infect vegetables grown on it." He adds (18b) that "good epidemiological evidence seems to exist in the literature to the effect that fresh vegetables may and have caused communicable diseases and that the sanitary condition of the soil from which they are harvested is important." - and finally (18c) that "This review of the literature quite clearly indicates that fresh vegetables which are raised on polluted soil may transmit pathogenic bacteria."

19. Rider (19) in commenting on irrigation in Arizona notes the insanitary practices of many camps of agricultural workers and the use of the main canals for drinking water, swimming, washing clothes, etc. In spite of such conditions only a few instances were noted where water borne diseases were attributed to canal water. Several years ago, as the result of a newspaper syndicated article, the state laboratory undertook bacteriological examination of lettuce. Many heads -- from 16 fields in the Salt River Valley and from two in the Eloy district -- were cultured but no evidence of typhoid or allied organisms was found. Although the technique used was rather hastily devised, it was felt any general contamination would have been indicated.

20. The Committee on Sewage Disposal, American Public Health Association (20) notes in 1937, that "California, alone, out of 33 states reporting, ... has adopted regulations under its Public Health Act whereby the disposal of sewage, sewage effluent or sludge for irrigation or fertilizing purposes" requires a permit from the State Board of Health. Briefly these California Regulations require that raw sewage shall not be used for irrigating growing crops, and settled or undisinfected sewage is banned for the irrigation of growing vegetables, garden truck, berries, or low-growing fruit, or for watering vineyards or orchards where windfalls or fruit lie on the ground.

21. The Committee on Utilization of Sewage Sludge as Fertilizer, Federation of Sewage Works Associations, in their report (21) in 1942, notes the California regulations are still in effect. Several other states regulate or advise regarding use of sewage sludge.

22. Rawn (22) notes that as of June, 1934, 39 states and the District of Columbia had replied to a questionnaire on use of sewage for irrigation. Thirty states reported neither sewage nor sewage-polluted waters were used for irrigation within their boundaries. Seventeen of these states reported they would not tolerate such use, and the other 13 found it repugnant.

"In the 9 states which admitted use of sewage for irrigation, the attitude was one of tolerance ... and rigid regulations of the production of the effluent as well as the nature of the crops for which it was to be used."

23. DeMartini (23) mentions the following regulations concerning irrigation with sewage and sewage-laden waters:

(1) Colorado - "Requires written permission of State Board of Health for use of sewage or sewage-polluted waters when Coli-aerogenes group of bacteria exceeds 10 per cc."

(2) California and Oregon - "Prohibit use of raw sewage for irrigating growing crops. Prohibit use of settled or undisinfected sewage effluents on growing vegetables and garden truck. Highly oxidized and disinfected sewage effluents can be used provided they meet drinking water standards in Oregon and in California if not over 10% of 10cc. portions are positive for the Coli-aerogenes group. Also no single sample can be positive for over half of the 0.1 cc. portions examined."

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APPENDIX F

SUMMARY OF INDIVIDUAL RESULTS

NORTH PLATTE RIVER BASIN

Page

Alcova Reservoir to Guernsey Reservoir 149

Below Guernsey Reservoir to Lake McConaughy 151

LABORATORY DATA
SUMMARY OF RESULTS

Sampling Point	Mileage from Mouth	Date	Avg disch c.f.s	Temp °C	Dissolved Oxygen		5 Day B.O.D. p.p.m.	Coliforms M.P.N. Per 100 ml.	pH	Turb p.p.m.	Alkalinity p.p.m.			Cl p.p.m.	Nitrogen - N p.p.m.			PO4 p.p.m.
					p.p.m.	% Sat. (1)					Phth.	M.O.			NH_3	NO_2	NO_3	
Alcova Reservoir	N.P. 442.0	7/12/50			8.8				8.4		10	116						
	"	8/24/50			8.7				8.5	(a)	10.5	116						(b)
	"	10/13/50		14	8.0	93.4			8.5	(a)	8.0	113						(b)
300 yards below Alcova Reservoir	N.P. 441.8	8/24/50			8.7				8.5	(a)	10.5	116						(b)
	"	10/13/50		24	4.4	62.5			8.0	(a)	0.0	108						(b)
At Bino Gulch, Wyo.	N.P. 438.0	7/13/50			8.8				8.4		2.5	116						
	"	10/13/50		17	7.2	89.6			8.3	(a)	2.0	111						(b)
Wyoming Highway #220, Bridge	N.P. 427.2	7/12/50			8.8				8.4		2.5	116						
	"	10/13/50		17	8.8	119.4			8.4	66	4.5	186						(b)
Confluence of Cottonwood Creek and North Platte River	N.P. 415.0	7/13/50			8.8				8.4		4.0	121						
	"	10/13/50		17	10.4	129.4			8.1	(a)	2.0	167						(b)
1/2 mile west of Mills, Wyoming	N.P. 401.0	8:30 A 2/8/50	65	0	11.34	94.0	1.0		8.3	3		178		33				
	"	9:20 A 2/12/50	78	1	11.19	95.3	0.9		8.2	8		177		31				
	"	8:50 A 2/14/50	72	1	10.90	92.8	1.4		8.3	3		181		40				
	"	7:40 A 2/16/50	75	1	10.61	90.4	1.4		8.4	8		182		36				
At Mills, Wyoming	N.P. 399.3	7/13/50			8.8				8.4									
	"	10/13/50		16	8.8	107.1			8.2	40	5.5	160						(b)
Bridge below Oil Refinery in Casper, Wyoming	N.P. 397.0	12/8/49		9	7.2	75.3	22.0											
	"	7/13/50			8.0				8.4		3.5	120						
	"	10/14/50		16	4.8	58.5			8.0	55	0.0	161						(b)
Texaco Bridge above Oil Refinery sewer outfall	N.P. 3[illegible].0	10/14/50		18	9.6	122.0			8.2	(a)	5.0	166						(b)
Mystry Bridge - below Casper, Wyoming	N.P. [illegible].5	10/25/49			6.2		19.0											
	"	10/28/49			6.0		3.8											
	"	12/7/49		1	5.4	46.0	16.0											
	"	10:00 A 2/8/50	65	2	3.99	34.9	20.2		8.3	18		183		45				
	"	10:05 A 2/12/50	78	3	1.88	16.9	29.7		8.1	6		195		31				
	"	10:20 A 2/14/50	72	3	2.51	22.6	25.0		7.9	19		188		74				
	"	9:15 A 2/16/50	75	4	2.23	20.6	24.0		8.3	18		206		73				
	"	7/13/50			7.6				8.4		3.5	118						
	"	10/14/50		19	12.0	155.4			8.4	(a)	8.0	151						(b)
Bridge at Parkerton Wyoming	N.P. 378.0	7/13/50			7.6				8.4		3.5	118						
	"	8/25/50			8.0				8.5	25	10.5	114						(b)
	"	10/14/50		17	17.6	218.9			8.7	(a)	20.0	144						(b)

(1) Percent saturation based on barometric pressure of 687 mm.
(a) Less than 25 p.p.m. turbidity.
(b) Less than 0.1 p.p.m. phosphate.

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LABORATORY DATA
SUMMARY OF RESULTS

Sampling Point	Mileage from Mouth	Date	Avg disch c.f.s	Temp. °C	Dissolved Oxygen		5 Day B.O.D.	Coliforms M.P.N. Per 100 ml.	pH	Turb p.p.m.	Alkalinity p.p.m.			Cl p.p.m.	Nitrogen - N p.p.m.			PO₄
					p.p.m	(1) % Sat.	p.p.m.				Phth.	M.O.			NH₃	NO₂	NO₃	p.p.m
Above Oil Refinery at Glenrock, Wyoming	N.P. 367.0	12/7/49		1	13.8	117.5	6.6											
	"	11:00 A 2/10/50		1	7.46	63.5	2.6		8.3	11		193		40				
	"	10:45 A 2/12/50		1	6.03	51.4	5.0		7.8	3		192		53				
	"	11:05 A 2/14/50		1	7.25	61.8	3.6		8.2	5		200		40				
	"	9:50 A 2/16/50		1	7.09	67.2	3.2		8.4	9		189		52				
Bridge at Glenrock, Wyoming	N.P. 365.6	12/7/49		1	13.20	112.4	7.0											
	"	7/13/50			7.60				8.4		3.5	118						
	"	8/25/50			7.60				8.5	25	11	116						(b)
	"	10/15/50		16	12.80	155.9			8.5	(a)	12	153						Tr.
5 miles below Glenrock, Wyoming	N.P. 361.0	12/7/49		1	12.60	107.3	5.4											
	"	12:20 P 2/8/50		1	8.21	69.9	3.8		8.3	8		192		44				
	"	11:15 A 2/12/50		1	7.08	60.3	4.2		8.0	3		202		44				
	"	11:25 A 2/14/50		1	8.02	68.8	4.0		8.3	3		202		35				
	"	10:10 A 2/16/50		1	8.78	74.8	3.0		8.3	10		187		38				
Careyhurst, Wyoming	N.P. 357.0	7/14/50			7.20				8.2		2.5	118						
	"	10/15/50		17	10.40	189.4			8.4	(a)	6.0	152						(b)
Bridge above Douglas, Wyoming	N.P. 326.0	12/7/49		1	11.60	98.8	3.4											
	"	1:10 P 12/4/50	175	2	7.52	65.8	1.5		8.0	7		274		37				
	"	1:15 P 2/8/50	176	1	12.00	102.2	2.0		8.4	3		204		35				
	"	12:05 P 2/14/50	178	1	13.06	111.2	2.9		8.3	3		212		30				
	"	10:40 A 2/16/50	184	1	13.63	116.1	2.2		8.4	5		194		36				
2 miles below Douglas, Wyoming	N.P. 322.0	12/7/49		1	11.00	93.7	4.2											
	"	7/14/50			6.00				8.4		4.0	119						
	"	8/25/50			7.60				8.7	25	9.2	124						(b)
	"	10/15/50		16	8.80	107.2			8.4	(a)	9.0	169						(b)
Bridge at Orin Junction, Wyoming	N.P. 305.0	12/7/49		0	11.80	97.8	3.4											
	"	12:30 P 2/4/50		1	10.82	92.2	1.1		8.0	2		276		39				
	"	2:00 P 2/8/50		1	13.88	118.2	3.0		8.4	3		207		40				
		1:10 P 2/14/50		1			2.2		8.4	2		200		26				
	"	11:10 A 2/16/50		1	14.63	124.6	1.9		8.5	3		190		31				
	"	7/14/50			6.80				8.4		3.5	120						
Bridge East of Glendo, Wyoming	N.P. 283.5	7/14/50			6.40				8.3		3.5	120						
	"	10/15/50		14	9.60	112.1			8.5	(a)	10	162						(b)
Above Guernsey Reservoir at Wendover, Wyoming	N.P. 264.8	10:45 A 2/4/50	195	0	11.70	97.0	0.7		8.2	2		273		22				
	"	3:15 P 2/8/50	197	1	12.49	106.4	2.0		8.5	4		200		29				
	"	2:30 P 2/14/50	200	1	12.67	107.9	1.6		8.4	2		193		25				
	"	12:20 P 2/16/50	210	2	12.71	111.3	1.2		8.5	3		180		29				

(1) Percent saturation based on barometric pressure of 627 mm.
(a) Less than 25 p.p.m. turbidity.
(b) Less than 0.1 p.p.m. phosphate.

LABORATORY DATA
SUMMARY OF RESULTS

Sampling Point	Mileage from Mouth	Date	Avg disch c f s	Temp °C	Dissolved Oxygen p.p.m	Dissolved Oxygen (2) % Sat	5 Day B.O.D. p.p.m.	Coliforms M.P.N. Per 100 ml.	pH	Turb p.p.m.	Alkalinity p.p.m. Phth.	Alkalinity p.p.m. M.O.		Cl p.p.m.	Nitrogen-N p.p.m. NH_3	Nitrogen-N p.p.m. NO_2	Nitrogen-N p.p.m. NO_3	PO_4 p.p.m.
Bridge at Guernsey, Wyoming	N.P. 849.5	11/30/49		6	10.8	94.4	1.8											
	"	12/3/49		5	10.2	92.0												
3 miles below Guernsey, Wyoming	N.P. 846.0	11/30/49		6	11.8	109.2	1.6											
Bridge at Ft. Laramie, Wyo.	N.P. 833.0	11/30/49		6	10.6	98.0	2.8											
	"	12/3/49		5	10.8	97.5												
	"	8/26/50			7.6				8.3	(a)	8.5	136						(b)
Bridge 2 miles south of Lingle, Wyoming	N.P. 820.0	11/29/49		8	11.0	107.0	2.3											
		12/2/49		6	11.0	101.8												
Vaughn Bridge 4 miles N.W. of Torrington, Wyoming	N.P. 815.0	9:45 A 10/24/50	444	10	10.03	102.2	2.1	2,400	8.2	15		223			1.140	0.020	<0.02	
	"	9:40 A 10/26/50	415	10	9.65	98.4	1.5	4,600	7.9	10		228			0.980	0.030	0.60	
	"	10:00 A 10/30/50	349	9	9.78	97.5	0.6	430	8.1	5		234			0.880	0.025	0.70	
	"	9:55 A 11/1/50	368	9	9.35	93.8	0.7	4,600	8.1	5		242			1.080	0.025	0.80	
	"	9:40 A 11/3/50	362	5	10.40	93.9	1.6	930	7.9	5		226			1.800	0.020	0.80	
	"	11/8/50		3	10.80				8.3		7	210						(b)
Bridge at Torrington, Wyoming	N.P. 808.6	11/29/49			10.20													
	"	12/2/49		8	10.40	101.2	1.0											
	"	12/5/49		1	11.00	89.3												
	"	11/8/50		3	10.80	98.5			8.3		7	208						(b)
1/2 mile downstream from Hwy.Bridge at Torrington, Wyoming	N.P. 808.0	11/30/49		5	9.6	86.6												
1/2 mile below sewer outfall, Torrington's city dump	N.P. 807.0	12/1/49			10.4		8.2											
Walk-in 4 miles below sugar factory sewer outfall - Goering Ranch	N.P. 804.0	10:30 A 10/24/50	437	11	5.23	55.8	37.9	93,000	7.7	120		294			1.040	0.069	0.90	
	"	10:15 A 10/26/50	415	10	5.30	54.0	33.4	9,300	8.0	100		292			0.980	0.068	0.90	
	"	10:40 A 10/30/50	349	10	5.30	54.0	43.0	4,300	8.1	95		286			0.960	0.062	0.90	
	"	10:30 A 11/1/50	362	10	5.78	58.9	27.1	46,000	8.3	100		289			1.180	0.064	1.60	
	"	10:50 A 11/3/50	356	5	7.05	63.6	36.2	24,000	8.3	110		307			1.640	0.060	1.00	
State Line Gaging Station	N.P. 799.5	11/29/49		15	6.90	76.5												
	"	12/1/49		8	7.40	72.0												
	"	12/2/49		8	7.40	72.0												
	"	12/3/49		1	9.00	73.0												
	"	12/5/49		1	8.60	69.8	26.0											
	"	12/5/49		1	8.80	66.6	38.0											
	"	5:00 A 6/15/49		16	3.49	40.5	0.8	150,000	7.9	9,500		208		15	0.180	0.001	0.85	
		4:10 A 6/22/49		20	6.86	78.8	1.1	9,300	8.0	800		199		15	0.010	<0.001	0.32	
		6:30 A 6/27/49		17	7.71	91.4	3.7	9,300	7.9	100		214		17	0.100	<0.001	0.80	0.15

(2) Percent saturation based on barometric pressure of 658 mm.
(a) Less than 25 p.p.m. turbidity.
(b) Less than 0.1 p.p.m. phosphate.

LABORATORY DATA
SUMMARY OF RESULTS

Sampling Point	Mileage from Mouth	Date	Avg disch cfs	Temp °C	Dissolved Oxygen p.p.m.	Dissolved Oxygen % Sat (a)	5 Day B.O.D. p.p.m.	Coliforms M.P.N. Per 100 ml	pH	Turb p.p.m.	Alkalinity p.p.m. Phth.	Alkalinity p.p.m. M.O.		Cl p.p.m.	Nitrogen-N p.p.m. NH3	Nitrogen-N p.p.m. NO2	Nitrogen-N p.p.m. NO3	PO4 p.p.m.
County Bridge 1 mile south of Henry, Nebraska	N.P. 199.0	11:30 A 10/24/50	483	12	6.41	68.3	20.6	93,000	7.7	85		263			1.280	0.079	0.90	
	"	11:10 A 10/26/50	408	11	5.85	60.9	27.0	9,100	8.0	85		268			0.980	0.084	0.80	
	"	11:30 A 10/30/50	349	10	5.63	57.4	25.5	46,000	7.9	90		282			0.760	0.086	0.60	
	"	12:15 P 11/1/50	356	11	5.88	61.2	24.0	110,000	8.2	100		300			1.080	0.086	0.70	
	"	11:40 A 11/3/50	350	5	6.55	59.1	25.3	43,000	8.0	180		282			1.800	0.079	0.80	
	"	11/8/50		3	7.00	60.0			8.1		3	245						(b)
Walk In - 800 yards above Tri-State Diversion Dam	N.P. 198.3	Noon 11/3/50	349	5	7.60	68.6	22.8	9,100	8.0	110		278			1.800	0.072	0.80	
Walk In - Tri-State Diversion Dam 1/2 mile east of Henry, Nebraska	N.P. 198.2	4:25 A 6/15/49	970	17	7.23	85.8	1.3	530	8.2	290		207		13	0.200	0.001	0.40	
	"	3:55 A 6/22/49	1,380	20	6.19	78.0	1.5	9,300	8.0	200		207		13	0.140	0.004	0.32	
	"	6:05 A 6/27/49	1,100	18	7.12	86.2	1.2	24,000	7.9	120		195		14	0.080	<0.001	0.28	0.05
Walk In - 100 feet below Tri-State Diversion Dam	N.P. 198.1	12:20 P 11/3/50	349	5	7.90	71.3	21.6	43,000	8.0	120		282			1.800	0.086	0.90	
Horse Creek - 1 mile north and 1 3/4 miles east of Lyman, Nebraska	N.P. 196.0 Ho.Cr.4.0	5:50 A 6/15/49	397	18	7.11	86.1	2.9	2,100	8.2	700		241		14	0.140	<0.001	0.16	
	"	4:53 A 6/22/49	110	19	6.25	77.2	3.5	930	8.4	230		263		15	0.090	0.003	0.64	
	"	7:00 A 6/27/49	142	18	7.54	91.3	3.8	4,300	7.9	400		206		13	0.040	0.002	0.40	0.12
	"	Noon 10/26/50		10	11.10	113.1	1.8	15,000	8.2	35		412			0.84	0.085	0.80	
Bridge - Horse Creek, Northeast edge of Lyman, Nebraska	N.P. 196.0 Ho.Cr. 2.6	5:30 A 6/15/49		18	6.64	80.4	2.8	4,300	8.2	600		240		14	0.180	<0.001	0.20	
	"	4:30 A 6/22/49		20	6.37	80.2	1.9	430	8.5	280		267		16	0.100	0.003	0.40	
	"	6:50 A 6/27/49		18	7.46	90.3	3.2	4,300	7.9	260		203		13	0.060	<0.001	0.32	0.12
	"	11:30 A 10/26/50		10	10.75	109.6	2.1	<3,600	8.3	35		426			0.88	0.016	Tr.	
County Bridge - 2 miles south of Morrill, Nebraska	N.P. 191.6	6:18 A 6/15/49	1,460	16	7.21	83.6	2.0	4,300	8.1	550		215		14	0.140	0.002	0.40	
	"	5:07 A 6/22/49	1,570	20	6.67	84.0	1.4	4,300	8.4	200		216		15	0.080	0.002	0.60	
	"	7:15 A 6/27/49	596	15	7.65	87.0	2.3	4,300	7.9	220		223		17	0.040	0.001	0.80	0.10
	"	Noon 10/24/50	636	11	7.03	73.2	13.7	43,000	7.8	75		274			1.080	0.072	0.60	
	"	12:15 P 10/26/50	615	12	6.80	72.5	12.1	9,100	8.0	55		268			0.980	0.060	0.80	
	"	11:50 A 10/30/50	560	11	6.58	68.5	13.1	9,100	7.9	50		288			0.760	0.064	0.50	
	"	1:20 P 11/1/50	575	11	7.08	73.1	10.6	46,000	8.1	80		299			0.900	0.059	0.50	
	"	12:50 P 11/3/50	580	5	8.80	79.4	11.0	93,000	7.9	85		274			1.840	0.051	0.90	
	"	11/8/50		3	8.60	73.7			8.1		3	299						(b)
County Bridge - 1/2 mile south of Mitchell, Nebraska	N.P. 185.2	6:40 A 6/15/49	1,910	16	7.41	86.0	1.7	4,300	8.1	500		219		15	0.140	0.003	0.48	
	"	5:30 A 6/22/49	1,860	19	6.94	85.7	1.4	24,000	8.2	180		212		16	0.050	0.002	0.80	
	"	7:36 A 6/27/49	646	16	8.08	93.7	2.9	9,300	7.9	210		241		17	0.060	0.001	2.40	0.15
	"	12:30 P 10/24/50	858	12	7.78	82.9	8.4	43,000	8.0	45		260			0.700	0.049	0.50	
	"	10:30 A 10/26/50	828	11	7.35	76.6	6.1	93,000	7.8	35		260			0.900	0.047	0.90	
	"	12:40 P 10/30/50	772	10	7.20	73.4	8.0	[illegible],000	8.0	50		303			0.900	0.050	0.50	
	"	9:35 A 11/1/50	768	9	7.03	70.1	6.0	23,000	7.8	55		300			1.320	0.053	0.80	
	"	8:25 A 11/3/50	793	5	7.75	69.9	7.2	75,000	8.0	75		298			1.600	0.062	1.20	
	"	11/9/50			10.40				8.1		2	245						(b)

(a) Percent saturation based on barometric pressure of 658 mm.
(b) Less than 0.1 p.p.m. phosphate.

LABORATORY DATA
SUMMARY OF RESULTS

Sampling Point	Mileage from Mouth	Date	Avg disch c.f.s	Temp °C	Dissolved Oxygen p.p.m.	Dissolved Oxygen % Sat. (a)	5 Day B.O.D. p.p.m.	Coliforms M.P.N. Per 100 ml.	pH	Turb p.p.m.	Alkalinity p.p.m. Phth.	Alkalinity p.p.m. M.O.		Cl p.p.m.	Nitrogen-N p.p.m. NH_3	Nitrogen-N p.p.m. NO_2	Nitrogen-N p.p.m. NO_3	PO_4 p.p.m.
Walk In - 1 3/4 mile S.E. of Mitchell - U.S.Hwy. #26, 1 mile south on County Road	N.P. 182.9	7:00 A 6/15/49	1,910	17	7.88	89.1	2.0	4,300	8.1	550		218		14	0.080	<0.001	0.40	
	"	5:55 A 6/22/49	1,060	19	6.55	80.9	2.0	9,300	8.2	180		211		15	0.100	0.002	0.60	
	"	7:55 A 6/27/49	646	16	7.46	86.6	1.8	9,300	8.1	160		250		19	0.040	0.001	2.40	0.10
	"	10:00 A 10/26/50	888	11	6.15	64.1	23.3	930,000	8.0	40		272			0.090	0.059	0.60	
	"	1:15 P 10/30/50	772	10	6.36	64.8	15.4	93,000	8.0	50		285			0.780	0.059	0.60	
	"	9:50 A 11/1/50	804	9	6.17	61.5	7.0	240,000	8.0	155		310			1.880	0.057	1.00	
	"	12:30 P 11/2/50	777	8	7.22	70.2	6.4	93,000	8.1	70		257			0.680	0.045	1.00	
	"	8:45 A 11/3/50	788	5	6.80	61.4	9.4	240,000	8.1	100		298			1.580	0.059	0.80	
20th Street Bridge, State Hwy. #26, 2 1/2 miles east of Scottsbluff, Nebraska	N.P. 178.0	7:25 A 6/15/49	2,190	17	7.20	85.4	1.8	4,300	8.2	500		224		15	0.140	<0.001	1.40	
	"	6:15 A 6/22/49	1,770	19	6.82	84.2	2.0	2,300	8.2	180		212		15	0.090	0.003	0.80	
	"	8:10 A 6/27/49	674	16	7.22	90.7	2.2	4,300	7.9	95		230		18	0.080	0.001	2.00	0.05
	"	12:50 P 10/24/50	1,030	18	7.23	77.1	11.0	240,000	8.0	55		270			0.900	0.043	0.60	
	"	9:00 A 10/26/50	960	10	6.95	[illegible]	7.3	240,000	8.1	40		282			0.800	0.047	0.80	
	"	9:05 A 11/1/50	970	9	7.20	71.8	5.5	240,000	8.0	55		302			1.080	0.048	1.40	
	"	Noon 11/2/50	950	8	5.91	57.5	10.1	23,000	8.1	75		291			0.880	0.058	1.30	
	"	8:05 A 11/3/50	955	5	7.60	68.6	6.1	43,000	8.1	65		316			1.740	0.042	1.20	
	"	11/9/50		2	10.80	85.1			8.1		2	245						(b)
Bridge at Scottsbluff, Nebraska	N.P. 173.8	8/27/50			7.80				8.3	100	3.8	224			-			(b)
Walk In - 4 miles east of Scottsbluff, Nebraska on U.S. Hwy. #26, 1 3/4 miles south on County Road. Everett's Farm	N.P. 170.0	8:30 A 6/16/49	2,190	17	7.40	87.3	2.0	15,000	8.2	460		220		16	0.100	0.001	1.40	
	"	7:15 A 6/22/49	1,770	20	6.97	87.8	2.8	15,000	8.1	160		213		16	0.060	0.002	0.80	
	"	9:05 A 6/27/49	674	18	7.71	93.3	2.4	9,300	7.9	90		232		19	0.140	0.002	3.20	0.05
	"	2:10 P 10/25/50	1,190	14	5.65	62.9	36.7	430,000	8.3	100		284			0.980	0.097	0.20	
	"	12:15 P 10/26/50	1,170	11	2.45	25.5	39.0	36,000	8.3	95		302			0.960	0.150	0.60	
	"	2:40 P 10/31/50	1,140	14	5.28	58.8	46.6	240,000	8.1	250		316			1.000	0.107	1.00	
	"	11:00 A 11/1/50	1,140	11	5.18	54.0	34.5	230,000	7.8	1,000		396			0.980	0.092	1.00	
	"	11:20 A 11/2/50	1,130	8	5.95	57.9	44.0	240,000	8.3	170		342			0.780	0.095	1.00	
	"	9:35 A 11/3/50	1,120	5	5.75	51.9	33.1	150,000	8.3	160		348			1.900	0.083	1.00	
County Bridge N.E. edge of Melbeta, Nebraska	N.P. 165.6	4:30 A 6/17/49	1,700	18	6.62	80.1	2.8	46,000	8.6	330		232		19	0.080	0.002	1.40	
	"	7:30 A 6/22/49	1,790	20	7.14	89.9	1.9	2,300	8.2	230		219		17	0.120	0.002	0.80	
	"	9:25 A 6/27/49	694	19	7.69	94.9	1.8	15,000	7.9	170		250		19	0.060	0.001	2.40	0.15
	"	8/27/50			6.80				8.2	185	4.0	214						(b)
	"	2:30 P 10/23/50	1,240	13	3.57	38.9	19.4	93,000	7.7	70		296			1.04	0.125	1.10	
	"	11:10 A 10/25/50	1,130	11	4.90	51.0	19.5	460,000	8.2	75		290			0.84	0.100	0.50	
	"	10:45 A 10/27/50	1,140	10	4.68	47.7	16.3	<36,000	8.1	55		290			0.96	0.097	0.40	
	"	11:30 A 10/31/50	1,140	12	4.62	49.2	18.2	93,000	7.9	95		312			0.90	0.113	0.60	
	"	9:50 A 11/2/50	1,130	9	3.90	38.9	22.0	240,000	8.1	110		386			1.00	0.113	0.60	
	"	11/9/50		1	8.20	66.6			8.1		2	259						(b)
County Bridge, 1/4 mile north of McGrew, Nebraska	N.P. 159.5	4:52 A 6/17/49	1,700	18	6.75	81.7	2.7	110,000	8.4	370		225		18	0.080	<0.001	1.400	
	"	7:48 A 6/22/49	1,790	21	6.80	87.4	2.0	24,000	8.2	290		221		17	0.015	0.002	1.00	
	"	9:40 A 6/27/49	694	19	7.72	95.3	2.3	46,000	7.9	180		242		19	0.060	<0.001	<0.02	0.12

(a) Percent saturation based on barometric pressure of 658 mm.
(b) Less than 0.1 p.p.m. phosphate.

LABORATORY DATA
SUMMARY OF RESULTS

Sampling Point	Mileage from Mouth	Date	Avg. disch c.f.s	Temp. °C	Dissolved Oxygen p.p.m	Dissolved Oxygen % Sat (2)	5 Day B.O.D. p.p.m.	Coliforms M.P.N. Per 100 ml.	pH	Turb p.p.m.	Alkalinity p.p.m. Phth.	Alkalinity p.p.m. M.O.		Cl p.p.m.	Nitrogen-N p.p.m. NH_3	Nitrogen-N p.p.m. NO_2	Nitrogen-N p.p.m. NO_3	PO_4 p.p.m.
County Bridge, 1/4 mile north of McGrew, Nebraska	N.P. 155.5	8:10 P 10/23/50	1,840	13	4.50	49.0	11.4	24,000	7.8	50		255			0.940	0.132	0.90	
	"	10:40 A 10/25/50	1,180	10	4.67	49.6	12.2	93,000	8.1	75		290			0.900	0.104	0.40	
	"	10:20 A 10/27/50	1,150	10	4.43	45.2	11.6	<3,600	8.0	45		305			1.080	0.100	0.30	
	"	11:05 A 10/31/50	1,140	10	3.93	40.1	14.0	93,000	8.0	100		321			0.780	0.181	0.70	
	"	9:30 A 11/2/50	1,140	9	3.60	35.9	15.8	150,000	8.1	85		316			1.040	0.107	0.60	
	"	11/9/50		2	8.00	66.8			8.1		2	270						(b)
County Bridge, 1 1/2 miles south of Bayard, Nebraska	N.P. 154.6	5:30 A 6/17/49	1,780	18	7.14	86.4	1.9	24,000	8.4	360		229		17	0.050	0.001	1.40	
	"	8:10 A 6/22/49	1,880	21	6.81	87.5	1.7	21,000	8.2	300		219		17	0.050	0.002	1.00	
	"	9:57 A 6/27/49	776	20	7.74	97.5	1.8	23,000	7.9	130		248		20	0.060	0.001	<0.02	0.10
Union Pacific R.R. Bridge, 3 miles S.E. of Bayard, Nebraska	N.P. 152.5	10:35 A 10/31/50	1,270	11	6.32	65.8	8.0	240,000	7.9	90		316			0.900	0.700	1.10	
	"	9:00 A 11/2/50	1,280	9	5.70	56.8	7.9	240,000	8.0	120		340			0.880	0.750	0.50	
Walk In, Belmont Diversion Dam, 5 miles S.E. of Bayard, Nebraska	N.P. 151.0	10:10 A 10/25/50	1,360	10	6.80	63.2	8.3	240,000	8.2	60		282			0.820	0.064	0.40	
	"	9:50 A 10/27/50	1,310	9	6.97	69.5	6.6	43,000	8.0	40		293			1.080	0.063	0.20	
	"	9:45 A 10/31/50	1,310	9	6.66	66.4	5.8	150,000	7.9	70		322			0.880	0.068	1.10	
	"	8:30 A 11/2/50	1,300	9	6.00	59.8	5.1	43,000	8.1	65		336			0.960	0.046	0.40	
50 feet below Belmont Diversion Dam	N.P. 150.9	9:25 A 10/31/50	1,310	9	7.40	73.8	6.3	43,000	8.0	85		298			0.900	0.680	0.20	
Wildhorse Canyon Canal 1/2 mile north of Bayard, Nebraska	N.P. 149.5 Bay.Can.5.8 Wh.Can. 1.2	12:40 P 10/23/50		14	8.57	95.4	1.5	4,300	8.4	85		220			1.360	0.023	0.80	
	"	8:50 A 10/25/50		10	9.03	98.0	1.2	910	7.8	15		220			0.960	0.010	<0.02	
County Bridge, south city limits of Bayard, Nebraska	N.P. 149.5 Bay.Can. 5.8	6:50 A 6/17/49		14	8.38	93.3	0.8	24,000	8.3	80		218		18	0.040	0.002	1.40	
	"	8:30 A 6/22/49		16	7.97	92.4	0.9	>110,000	8.4	95		216		18	0.050	0.002	2.00	
	"	10:20 A 6/27/49		18	8.25	99.9	2.1	9,300	8.3	85		228		19	0.080	0.00[illegible]	4.00	0.05
Bayard Canal, County Bridge, 1/2 mile south of Bayard, Nebraska	N.P. 149.5 Bay.Can. 3.9	6:40 A 6/17/49		14	8.11	90.3	1.1	24,000	8.4	85		232		20	0.060	0.010	4.00	
	"	8:20 A 6/22/49		17	8.02	95.1	1.1	46,000	8.1	110		228		19	0.010	0.002	1.40	
	"	10:10 A 6/27/49		18	7.75	93.8	2.4	150,000	7.9	80		232		19	0.280	0.007	4.00	0.10
	"	1:00 P 10/23/50		14	8.60	95.8	2.8	150,000	8.2	25		220			0.900	0.086	0.70	
	"	9:20 A 10/25/50		10	9.10	98.8	1.2	240,000	8.1	15		226			1.000	0.012	1.40	
Bridge, Hwy. #86 at Bridgeport, Nebraska	N.P. 141.8	7:42 A 6/17/49	1,770	19	7.34	90.6	1.4	15,000	8.6	380		225		18	0.050	0.004	1.20	
	"	9:20 A 5/22/49	2,150	21	6.91	88.8	1.8	9,300	8.1	250		220		18	0.050	0.001	1.00	
	"	11:00 A 6/27/49	827	21	7.47	96.0	2.8	4,300	8.2	120		245		21	0.060	<0.001	<0.02	0.05
	"	8/28/50			7.4				8.3	185		222						(b)
	"	12:15 P 10/25/50	1,600	12	8.10	86.4	7.4	93,000	8.3	50		274			0.790	0.051	0.40	
	"	11:40 A 10/27/50	1,600	10	7.85	80.0	4.7	240,000	8.3	75		282			0.980	0.050	0.40	
	"	1:30 P 10/30/50	1,530	13	7.70	83.9	5.0	240,000	8.1	75		301			0.920	0.050	0.60	
	"	12:20 P 10/31/50	1,530	12	7.85	83.7	5.3	75,000	8.0	75		380			1.120	0.053	0.50	
	"	11:20 A 11/2/50	1,490	9	7.95	79.3	5.1	240,000	8.1	75		316			0.900	0.053	0.50	

(2) Percent saturation based on barometric pressure of 658 mm.
(b) Less than 0.1 p.p.m. phosphate.

LABORATORY DATA
SUMMARY OF RESULTS

Samping Point	Mileage from Mouth	Date	Avg disch c f s	Temp °C	Dissolved Oxygen p p m	Dissolved Oxygen % Sat	5 Day B O D p.p.m	Coliforms M P N Per 100 ml.	pH	Turb p p m	Alkalinity p.p.m Phth.	Alkalinity p.p.m M O		Cl p p m	Nitrogen-N p p m NH₃	Nitrogen-N p p m NO₂	Nitrogen-N p p m NO₃	PO₄ p.p.m
Walk In - County Road 1 1/4 mile east of Bridgeport, Nebraska	N.P. 139.0	9:35 A 6/22/49	2,260	22	6.64	86.8	2.4	24,000	8.3	260		228		18	0.100	0.001	0.60	
	"	11:1? A 6/27/49	864	22	7.28	95.2	5.2	110,000	8.3	130		259		22	0.200	<0.001	<0.02	0.30
	"	11:?0 A 10/25/50	1,620	12	8.12	86.6	3.8	240,000	8.0	40		274			0.880	0.050	0.60	
	"	11:25 A 10/27/50	1,680	10	8.49	86.5	3.6	43,000	8.3	50		280			0.980	0.032	0.90	
	"	1:05 P 10/30/50	1,550	13	7.70	83.9	4.8	93,000	8.1	75		307			0.700	0.043	0.80	
	"	[illegible] 10/31/50	1,540	12	7.90	84.2	4.8	93,000	8.1	60		312			0.980	0.046	0.90	
	"	10:45 A 11/2/50	1,510	9	7.78	77.6	4.6	150,000	8.0	70		300			0.900	0.041	0.70	
Walk In - County Road, 1 mile south and 2 1/2 miles N. W. of Broadwater, Nebr.	N.P. 130.2	8:17 A 6/17/49		20	7.67	96.6	1.9	15,000	8.4	400		235		18	0.060	0.001	1.20	
	"	10:25 A 6/22/49		22	6.57	85.9	3.3	9,300	8.4	380		219		17	0.050	0.002	0.80	
	"	12:10 P 6/27/49		24	7.63	103.2	2.9	2,300	8.1	140		260		21	0.080	<0.001	0.40	0.05
County Bridge south of Broadwater, Nebr.	N.P. 128	8/28/50			7.20				8.3	275	5.5	232						(b)
	"	11:00 A 10/25/50	1,650	11	8.83	98.0	4.3	240,000	8.0	40		274			0.880	0.050	0.60	
	"	10:45 A 10/27/50	1,650	10	8.77	89.4	3.3	<36,000	8.3	50		280			1.080	0.028	0.70	
	"	12:40 P 10/30/50	1,580	12	8.21	87.5	4.4	46,000	8.1	70		294			0.800	0.032	0.50	
	"	11:30 A 10/31/50	1,570	11	8.58	89.4	3.4	24,000	8.2	85		322			1.040	0.035	0.80	
	"	10:15 A 11/2/50	1,540	9	8.80	87.7	5.1	43,000	8.3	95		306			0.680	0.030	0.60	
Walk In - County Road 3 miles S.E. of Broadwater, Nebr.	N.P. 125.7	8:35 A 6/17/49	2,380	20	7.48	94.2	1.7	7,500	8.4	400		234		18	0.050	0.002	1.40	
	"	10:35 A 6/22/49	2,620	23	6.87	91.4	1.9	15,000	8.3	390		220		17	0.120	<0.001	0.60	
	"	12:25 P 6/27/49	964	25	8.00	110.2	3.5	4,300	8.5	140		246		20	0.080	<0.001	0.04	0.12
County Bridge south of Lisco, Nebraska	N.P. 114.5	10:25 A 10/25/50	1,700	11	9.30	96.9	2.8	23,000	8.2	40		264			0.700	0.017	0.50	
	"	10:15 A 10/27/50	1,760	10	9.06	92.4	3.0	43,000	8.5	60		276			0.880	0.021	0.80	
	"	12:05 P 10/30/50	1,790	12	8.80	93.8	3.8	21,000	8.2	80		293			0.980	0.027	0.60	
	"	11:00 A 10/31/50	1,740	11	8.95	93.2	2.8	46,000	8.2	80		316			0.900	0.036	0.40	
	"	9:45 A 11/2/50	1,730	9	9.80	91.7	3.6	43,000	8.2	80		306			0.880	0.019	0.60	
Bridge, State Hwy.#27, 1 1/2 miles south of Oshkosh, Nebraska	N.P. 99.0	9:36 A 6/17/49	2,380	22	7.10	92.8	2.3	4,300	8.4	650		232		18	0.050	0.002	4.00	
	"	11:30 A 6/22/49	2,580	25	6.80	93.7	2.4	4,300	8.4	500		224		18	0.050	0.001	0.80	
	"	1:15 P 6/27/49	1,120	27	7.72	110.4	4.4	2,300	8.4	180		221		21	0.060	0.001	0.04	0.12
	"	8/28/50			6.20				8.3	550	6.5	244						(b)
	"	9:45 A 10/25/50	1,890	10	9.80	99.9	2.6	4,300	8.3	45		266			0.760	0.012	0.50	
	"	9:35 A 10/27/50	1,830	10	9.41	95.5	2.4	3,600	8.5	55		276			0.880	0.011	0.90	
	"	11:30 A 10/30/50	1,650	11	9.30	96.9	3.2	4,300	8.2	80		287			0.820	0.014	0.60	
	"	10:20 A 10/31/50	1,610	10	9.30	94.8	2.5	9,300	8.1	90		286			[illegible]	0.019	0.40	
	"	9:10 A 11/2/50	1,700	9	9.60	95.7	2.9	46,000	8.2	90		306			0.820	0.014	0.30	
Bridge 1/2 mile south of Lewellen, Nebr.	N.P. 84.5	10:25 A 6/17/49	2,710	23	7.09	94.3	1.6	24,000	8.3	500		198		13	0.140	0.004	1.40	
	"	12:30 P 6/22/49	2,780	26	7.73	106.6	2.5		8.4	450		189		13	0.050	0.001	0.80	
	"	1:?? P 6/27/49	1,800	28	6.58	105.1	5.0	2,300	8.3	160		200		17	1.000	0.001	0.14	0.20
	"	9:05 A 10/25/50	1,990	9	9.70	96.7	1.7	7,500	8.3	55		260			0.840	0.010	0.50	
	"	9:10 A 10/27/50	1,970	10	9.48	96.6	2.3	43,000	8.2	60		274			0.960	0.010	1.00	

LABORATORY DATA
SUMMARY OF RESULTS

Sampling Point	Mileage from Mouth	Date	Avg disch c f s	Temp °C	Dissolved Oxygen p p m	Dissolved Oxygen % Sat (2)	5 Day B O D p p m	Coliforms M P N Per 100 ml	pH	Turb p p m	Alkalinity p p m Phth.	Alkalinity p p m M. O		Cl p p m	Nitrogen-N p p m. NH_3	Nitrogen-N p p m. NO_2	Nitrogen-N p p m. NO_3	PO_4 p p m
Bridge 1/2 mile south of Lewellen, Nebr.	N.P. 68.8	11:05 A 10/30/50	1,950	11	9.30	96.9	3.2	930	8.3	80		284			0.360	0.015	0.90	
	"	9:30 A 10/31/50	1,900	10	9.40	95.8	2.5	9,300	8.3	80		300			0.880	0.016	0.80	
	"	8:40 A 11/2/50	1,900	9	9.62	95.9	3.0	24,000	8.1	180		292			0.720	0.010	0.50	
Lake McConaughy	N.P. 69.5	8/28/50			7.20				8.5	(a)	7.5	168						(b)

(2) Percent saturation based on barometric pressure of 658 mm.
(a) Less than 25 p.p.m. turbidity.
(b) Less than 0.1 p.p.m. phosphate.